MINERAL DEVELOPMENT IN ODISHA

– A personal view

G.H. Khuntia

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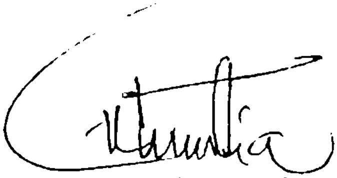

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TSAVORITE
GARNET

In 1972, a rich emerald-green variety of grossular garnet was found in the Taita Hills near the Tsavo Game Park in Kenya. The trade name Tsavorite was given the new gemstone by Campbell Bridges, the Scottish geologist who discovered the deposit. Tsavorite is one of the rarest varieties of garnet, the birthstone for January. Stones of good color that weigh more than a few carats are considered quite rare. This extraordinary 16.60-carat gem is one of the finest known examples of this new gemstone.

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PREFACE

This book is a compilation of the articles written by Late G. H. Khuntia (both published and manuscript) at different phases.

Late G.H. Khuntia was former General Manager (Geology) of the Odisha Mining Corporation. He was having vast experience in the field of Mineral Exploration, Mineral Concession and different Rules & Regulations related to Mineral Development in the Country. He has published several articles in different news papers from time to time, both in Odiya and in English, on contemporary issues related to mining industry which were widely acclaimed. Some of the papers have been collected and compiled together in this book for reference of all concerned.

During late 1970s, 1980s & 1990s several gem deposits came to limelight in the State of Odisha. As the Chief of Geology Division of the Odisha Mining Corporation, he was directly associated with the exploration, exploitation, procurement, marketing, systematic development of gem deposits through joint venture collaboration and assisted sector company. He also took active part in formulation of gem policy of the State for optimum utilization of the valuable gemstone resources of Odisha. In the process, he has developed great expertise in the field of gemstones. After his retirement from services of the Odisha Mining Corporation, he has written a book on "GEMSTONES OF INDIA" giving a vivid account of gemstones, their classification, uses, science, geology and cultural linkage, world occurrences, gemstones of India and a national outlook for gem mining in India, which remains unpublished due to his sudden demise. The books written on gemstone by Indian Authors are very few in number. Therefore, it is thought to bring this in a printed format so that the same can be utilized for benefit of the society.

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ACKNOWLEDGEMENT

This book would not have been possible without the tremendous support provided by the following people:

Mrs. Nirupama Das, Senior Manager (Geology), Odisha Mining Corporation and Mrs. Tilotama Basa, Senior Manager (Geology), Odisha Mining Corporation for playing a crucial role in selecting many of the articles and publications written by our late father, translating many of the articles from Oriya to English and developing the content and structure of the book.

Our special thanks to Sri Nitin Pachhigar, Ex-Convenor of Gemstone Panel of the Gem and Jewellery Export Promotion Council and Valuer for coloured gemstones for Commissioner of Customes, Mumbai and Sri K T Ramchandran, Chief Gemmological Institute of India, Mumbai for providing guidance and support to the author for the article on 'Gemstones of India'.

We are grateful to Alpha Communication for converting all hand written notes, articles of Mr. G.H. Khuntia for publication.

We are also grateful to Jyoti Graphics for their coordination and full assistance in printing and publishing this book.

Finally, Mrs. Sikha Khuntia (our Mother) planted the idea for this book in our minds few months back and led this initiative from start to finish. She offered regular encouragement, support and guidance in helping it bring to fruition.

Regards

Rajiv Khuntia, Leena Pokhriyal and Pushpamitra Khuntia

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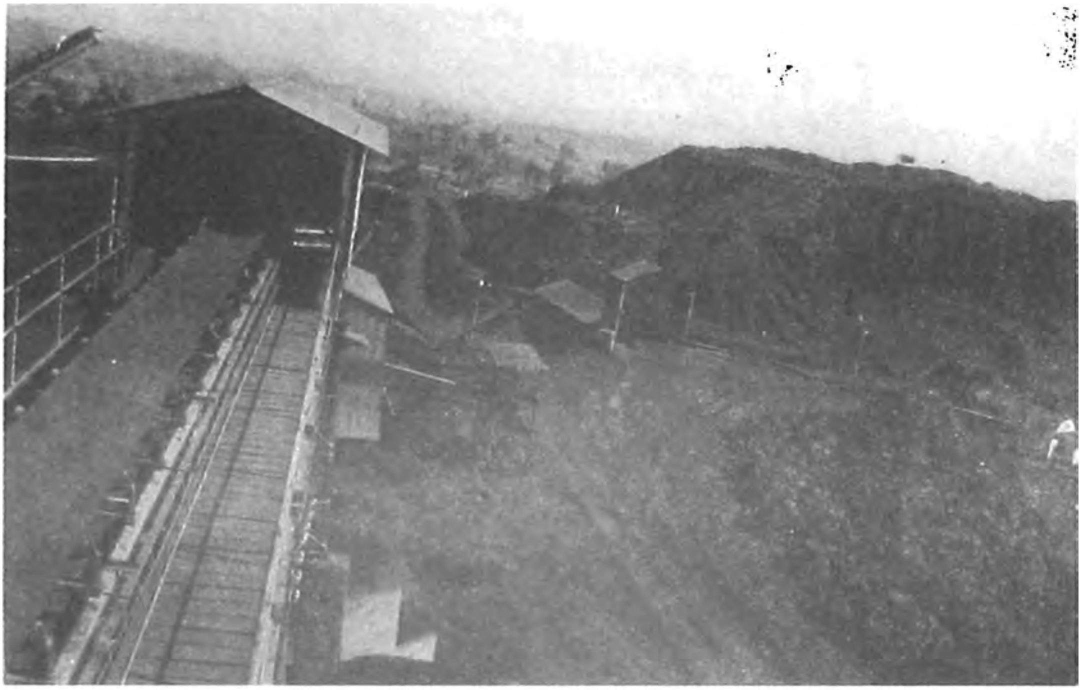

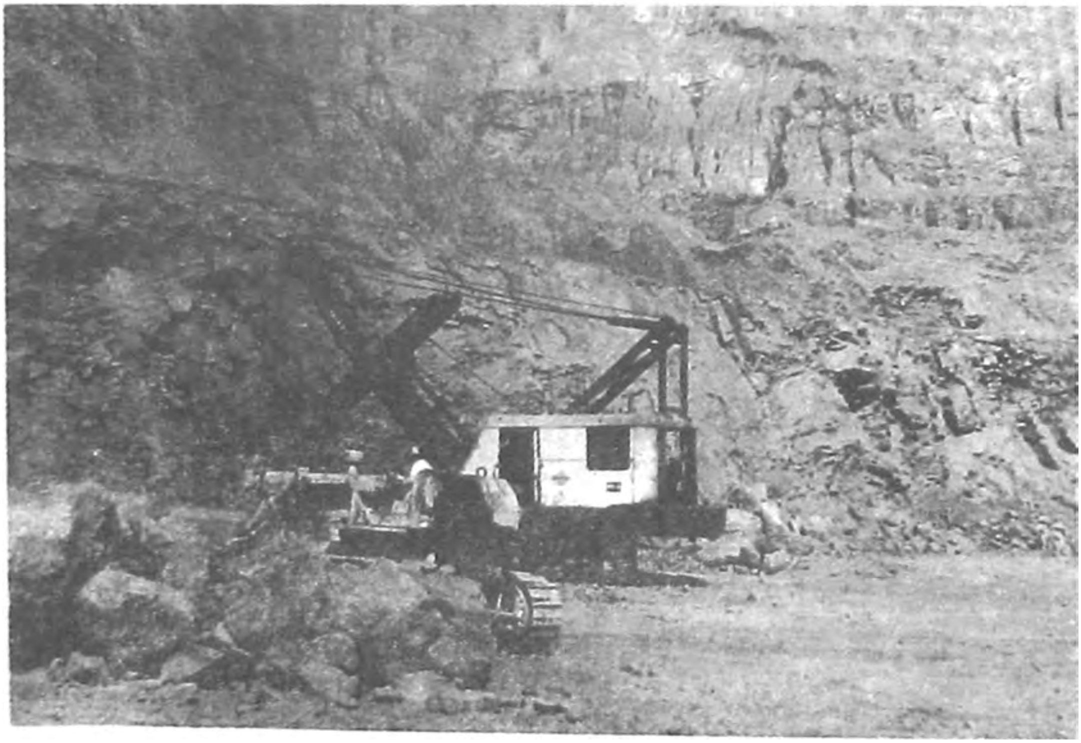

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MINING SCAM, ITS CAUSES AND PREVENTION (1)

There was an adjournment motion in the State Assembly for four days when the Opposition demanded for CBI enquiry and enquiry through Home Committee for illegal raising and trading of iron ore and manganese ore of crores of rupees inside the ML applied areas in Katasahi village of Keonjhar district by M/s Rambahadur Thakur. It is a matter of pleasure that even though firstly the State Govt. refused, later the Mining Minister ordered for an administrative enquiry by the Secretary, Steel & Mines and the Chief Minister has announced for Vigilance enquiry considering the gravity of the situation. Mineral resources are the wealth of Odisha and play a vital role in economic development of the State. There is no doubt that its misutilisation has created hesitation and anxiety in the minds of people.

Firstly, let us discuss the history of Katasahi Mining Lease of M/s Rambahadur Thakur. This Mining Lease was first given to Late S. N. Sen on 15th March, 1953 for 20 years. After this, the Govt. of Odisha invited application for grant of Mining Lease by notification no.7737 dated 6.8.1975. The Odisha Mining Corporation and Hindustan Steel (presently Steel Authority of India) applied for this lease, but as per notification no.10240/MG dated 4.8.1979 of the Department of Mining and Geology, Govt. of Odisha, this lease was given to Hindustan Steel for a period of 20 years from 16th January, 1980. After 10 years, Hindustan Steel surrendered this lease. So the Steel & Mines Department, Govt. of Odisha, vide notification no.8738/SM dated 25.7.1991, again invited applications for grant of Mining Lease. M/s Rambahadur Thakur directly applied only for manganese ore. Considering its application, the State Govt. decided to grant Mining Lease over 98.568 Hects. of area. This ML comprises 58.828 Hects. of non-forest and 37.74 Hects. of forest land. The company submitted approved Mining Plan to the Govt. as a prerequisite for grant of Mining Lease. The company applied to the Ministry of Environment and Forest, Govt. of India for permission for undertaking mining related work in forest area. But as it was not approved, the Govt. of Odisha has not granted Mining Lease even though 17 years have passed.

Secondly, M/s Rambahadur Thakur took permission from the State Govt. for one year to take up exploration in the area and also undertook the same. In this area, the company sank 8 nos. of pits and one trench and undertook drilling for 440 meters. During exploration, the occurrence of iron ore was discovered in the area besides manganese. It seems that the company has taken permission from the State Govt. for sale of manganese ore raised during exploration and transported more

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than 1500 tonne of manganese ore. As per rule 14 (II) (A) and (B) of the Mineral Concession Rule, 1960, there is provision for transport of maximum 200 tonnes of manganese ore from any executed PL area on non-commercial basis. But without any executed PL in this mining area, how the State Govt. permitted the company to undertake exploration and transport of manganese ore on commercial basis?

After the Forest conservation Act, 1980 came into force, without the permission of the Ministry of Environment and Forest, it is not possible to work in forest land even in executed leases. For this problem, many mines of the Odisha Mining Corporation and other companies are closed. Similarly without permission for working in forest area, grant of Mining Lease or Renewal of Mining Lease is not done. There is 37.58 Hects. of forest land in 96.58 hects. of area applied by M/s Rambahadur Thakur for Mining Lease. Here question arises how mining operation is being carried out in the alleged forest land ? What steps have been taken by the Forest Department to curb such illegal mining ? Besides, why the mining lease application of a company, who has not submitted required documents for grant of Mining Lease within a period of 17 years, has not been rejected? It is mentionable that on request of the company, the State Govt. permitted the company to safe guard the applied Mining Lease area at its own cost and has now withdrawn the permission. To permit any person or company, not having a Mining Lease, to safe guard a mining area by deploying security guards and deployment of security guards by the company are beyond the rules and regulations of mining. On the other hand, the State owned Odisha Mining Corporation has applied for ML over 416.835 Hects. of area in Chormalda village of Keonjhar District for manganese. The State Govt. has decided to grant this ML in favour of OMC; but due to availability of high grade manganese ore in the area, illegal mining and transport of manganese ore are going on from this area without any hindrance. The Chairman of the Odisha Mining Corporation has made the Collector, Keonjhar aware of the issue but so far no strong step has been taken to curb such illegal activity. It is seen from the above that in spite of required rules and regulations are in force, the mining scam is rampant and the Govt. is helpless.

Thirdly, from the information given by the Minister, Steel & Mines, the raising of minerals in the State has increased by 250% during the last 8 years. Accordingly, the mining revenue has also increased. In 2008-09 financial year, Rs.1380.52 crore of mining revenue was collected, where as during current year there is target of collecting mining revenue of Rs.1600 crore. With that the illegal mining has also increased. During the last financial year, 844 illegal mines have been located and fine for Rs.5.57 crore has been collected which is more than the mining revenue collected for many

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years during 1960-70. No rule is necessary for preventing illegal mining. What is the necessity of rules for mining where the transport of ores / minerals is done through false transit pass ? It is mentionable that during 31st October, 1981 to 1st January, 1994, the State Govt has framed so many rules for curbing illegal trading of gemstones. But it is a matter of regret that the prevailing rules for mining of gemstones is encouraging illegal mining, trading and establishment of lapidary centres in Odisha. So instead of mining rules, regulations are required at present.

Fourthly, as per Rule-4 of the Mines and Minerals Development and Regulation Act, 1957, no body without having a PL can undertake exploration and without having a ML can undertake mining, transporting and storing of minerals. So it is the responsibility of the Govt. to safe guard mineral resources in the areas where Mining Lease or licence has not been given. As per Rule 23 (C) of the MMDR Act, 1957, the State Govt. has been empowered to frame rules to prevent illegal raising, storing or transport of minerals. On the basis of this rule, the State Govt. has taken the right step by framing the Odisha Minerals (prevention of theft, smuggling & illegal mining and regulation of possession, storage, trading and transportation) Rule, 2007 to prevent illegal working of minerals. As per this rule, it is the responsibility of the State Govt. to safe guard mineral resources. It is seen that after enactment of this rule, the raising and illegal trading of iron ore and manganese ore in Keonjhar district has increased during the last 5 years. The value of confiscated ore during 2005-06, 2006-07 and 2007-08 were Rs.1.05 crore, Rs.1.97 crore and Rs.3.65 crore respectively; where as during 2008-09 it has reached Rs.7.6 crore. It means that the State Govt. has failed to utilize the rule properly.

At last, it appears that even though the State Govt. intends to utilize the rule, it has not been possible due to paucity of fund. To prevent the recent mining scam, it is very much necessary that the mining administration should be determined. If there is paucity of fund, the Govt should utilize the mining revenue collected from illegal mining activity to prevent such activity.The Govt. of Odisha should take decision on the matter as per rules. The amount of Rs.5.57 crore, collected during 2008-09 from illegal mining activities, should be utilized during 2009-10. More nos. of Flying Squad and Enforcement Squads should be constituted under the leadership of an Additional Director of Mines and provided with modern equipments. The existing rules should be strictly implemented. If this is done, there is no doubt that the mining scam in Odisha will be wiped out.

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MINING SCAM, ITS CAUSES AND PREVENTION (2)

Mineral resources play a vital role in the economic growth of our state. At the time of world-wide recession, the growth of mineral industries of the state has helped in the economic development of the nation. The largest project in which the Govt. of India has approved largest direct foreign investment is mineral based and it is a matter of pleasure that it is located in Odisha. But at present, massive corruption in the field of mining industrialization is a matter of great concern for the intellectuals. After clandestine mining and trading of iron and manganese ore within the applied Mining Lease of M/s Rambahadur Thakur in Katasahi village of Keonjhar District came to limelight, at first an article on *'Khani durnitira karana o nirakarana'* written by the author was published in the daily Samaj on 1st August, 2009. After that the Govt. of Odisha conducted administrative enquiry by the Secretary, Steel & Mines and Vigilance Department on the matter. After receiving required information and proof regarding clandestine mining and transportation during enquiry, the State Govt. has taken proper action against the officials of Mining, Geology and Forest Department and the Director of Mines who are involved. But the opposition party is not satisfied with the action taken by the State Govt. and has been pressurizing the Central Govt. for a CBI enquiry. The State Govt. has conducted an enquiry of the mining scam by constituting an Enforcement Squad. On receipt of information regarding massive irregularities and illegal trading of ore / minerals in the mines in Keonjhar and Sundargarh Districts, the State Govt. is continuing enquiry by Vigilance Department. In the meantime, the Vigilance Department has filed cases against 10 nos. of mines after conducting enquiry in 11 nos. of mines. The Ministry of Mines, Govt. of India is also conducting investigation in Odisha by a task force constituted by the Indian Bureau of Mines. It is known that this investigation team has issued notice for closure of 8 nos. of mines and asked for show-cause notice to 15 nos. of mines after receiving proof of irregularities in mining in many mines of Keonjhar and Sundergarh District during first week of December. Above all, the Odisha Citizen Forum has also drawn attention of the Hon'ble High court of Odisha by filing a PIL case on illegal mining and trading of minerals worth Rs.7000 crore per year from the mines in Odisha for the last so many years. The Hon'ble High court is investing the case through its Empowered Committee.

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Status of Mining Rules:

The status of Rules for Mines and Minerals is very transparent in our country. The item 54 of Union List of Schedule-7 of Indian Constitution has empowered the Govt. of India to regulate mines and minerals. Basing on the 'Industrial Policy Resolution 1956' of the Govt. of India, the Mines and Minerals (Development & Regulation) Act, 1957 has been enacted in which the purpose for development and regulation of mines and minerals has been laid down. Besides the earlier framed 'Mines Act, 1952' and 'Indian Explosive Act, 1957' for use of explosives in the mines, the' Mineral Concession Rules, 1960' and 'Mineral Conservation and Development Rules, 1988 were enforced by the Govt. of India for grant of Mining Leases and development, regulation & conservation of minerals. Similarly in view of conservation and use of forest land in mining activity, the 'Forest Conservation Act, 1980' and 'Forest Conservation Rules, 2003' have been enforced. For conservation and protection of environment in mining areas, the 'Environmental Protection Act, 1986' and 'Environmental Impact Assessment Notification, 2006 have become applicable. Similarly based on item 23 of State List of Schedule-7 of Indian Constitution, there is provision of regulation of mines and minerals by the State Govt. without defying the Rules framed by the Central Govt. In Section-23 (C) of Mines and Minerals Development and Regulation Act, 1957, the State Govt has been empowered to frame rules for curbing illegal mining and trading of minerals. Based on this, the State Govt. has framed the 'Odisha Mineral (Frevention of theft, smuggling, illegal mining and regulation of possession, storage, trading and transport) Rules, 2007.'

The reasons of mining scam:

On investigating the mining scam and irregularities in our state, the followings are observed to be the main reasons for the issue:

1. Raising of minerals without having a Mining lease and transporting it through fraud transit pass.
2. Illegal raising of gemstones and clandestine trading.
3. Selling of coal earmarked for a particular industry at concessional rate at a higher price elsewhere in the market and earning profit.
4. Mining beyond the surface right area granted by the collector.
5. Mining beyond the RML applied area.

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6. Mining under power of attorney without the consent of the Govt. of India.

7. Mining in the RML applied area without legal approval.

8. Mine development and raising beyond the limit that has been approved in the Mining Plan for the Mining Lease.

9. Mining in the forest and non-forest area without permission of the Ministry of Environment and Forest based on approved mining plan in the ML area as per 'Forest Conservation Act, 1980.

10. Mining without permission of the Ministry of Environment and Forest based on approved mining plan in the ML area as per 'Environment Protection Act, 1986.

11. Mining without permission of the Odisha Pollution Control Board for mine development and raising based on approved mining plan as per 'Prevention and Control of Pollution Act,1974' and 1981'.

On analyzing the above reasons, it is seen that the first 6 are under Mining Scam and others under irregularities.

Prevention of Mining Scam

Both the Central Govt. and State Govt. are responsible for controlling mining scam based on constitutional status and the prevailing rules. If we look into the status of law, the State Govt has to take steps to curb mining scam and the Central Govt. for putting an end to irregularities in mining. To achieve the above objectives, the co-operation of mine owners is very important. If the State Govt. or the Citizen Forum are thinking that mining scam is confined to 598 mining Lease areas, it is baseless. The base of mining scam due to loss of revenue is outside the mining lease area and it is out of control of the Govt. So to control mining scam and irregularities, both the State and Central Govt. are required to take well conceived and strong steps.

Firstly, when a Mining Lease is applied in our State, its grant and workability take unexpectedly long time which is encouraging illegal mining. In many Mining Leases for which renewal has been applied, the first 20 years of renewal period is over; and even if the 2nd renewal has been applied, the same has not been granted and lying in the files. Although there is question on its lawfulness, no body in the administration is responsible for its inordinate delay. I am feeling it proper to give

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an example which is fit to be placed in the Guinness Book of World Records on the issue. Sri Mantosh Ikath discovered chromite in Sukinda Valley. For this achievement, Sri Pitamber Bhupati Harichandan Mohapatra, the then King of Sukinda, granted Ikath a Mining Lease over an area of 680 acres in Gurujanga village for mining of chromite on 17.10.52 for a period of 20 years. After inclusion of the Sukinda province in the State of Odisha on 27.11.1952 and after nationalization of mining of chromite on 3.7.1962, the Govt. of Odisha cancelled this Mining Lease on 22.1.1970. After Sri Aikath took the shelter of law against this decision, the State Govt. decided to grant him mining Lease in Gurujang village over 140 Acres of area and signed agreement with him on 21.11.1984. Over all in 1987, the Honourable High Court of Odisha in a verdict of writ petitions on grant of Mining Lease to different industries as per recommendation of Sri B.K. Rao, the then Secretary, Ministry of Mines, Govt. of India directed the State Govt. to grant Mining Lease over 140 Acres of land in Gurujang village in favour of Sri Ikath in view of his contribution in discovering chromite in Sukinda valley. It is a matter of great regret that even though more than half a century (1952-2010) have passed, the problem of Mining Lease of 1952 remains unsolved as yet. Therefore, it is felt that the State Govt should successfully speed up the process of grant of Mining Lease and hold the administration responsible for grant of Mining Lease and its workability within the time limit.

Secondly as per rule 37 (2) of the Mineral Concession Rules, 1960, before entrusting the right of working in a Mining Lease to any person or organization, the lessee has to get the power of attorney approved by the Central Govt. under Rule-37(1). But in most of the cases they are managing to get the power of attorney without approval of the Central Govt. and trying to be millionaires by illegal mining and transport of minerals without any hindrance, with or without the knowledge of the State Govt. For early solution of the problem, the State Govt is required to verify all the power of attorneys and cancel illegal ones.

Thirdly, in comparison to other countries, even though our country has the largest nos. of rules & regulations on mines and raising of minerals in force, it is required to enforce these rules and regulations harmoniously for keeping a balance between the raising of minerals and conservation of environment. It seems that the mine owners are not aware of the purpose and workability of these rules. Information has been received that while discussing with the Central Empowered Committee of the Hon'ble Supreme Court, the Govt has admitted the fact of being not aware of some rules. It is the responsibility of the Govt. to execute the rules and regulations.

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When the Govt. itself is not aware of the rules and regulations, what more can be expected from the mine owners? Therefore, at present, the Govt. should make the mine owners aware of the workability of mining rules and their co-ordination. Out of 598 Mining Leases in our State, renewal has been applied for 351 nos. of leases where as 155 nos. of leases are under deemed extension under Section 24(A)(6) of Mineral Concession Rules, 1960. These mining leases are under the control of the Govt. In my opinion the State Govt. should organize a workshop of the mine owners, concerned officials and mining advisors. The Govt should regularize the mines having irregularities within one year and control them under prevailing rules. If any mine will continue irregularities, strong action should be taken against it.

Fourthly, the State Govt. is issuing trading license for purchasing, storing and selling minerals to traders who do not possess any mining lease or have ownership over a mine. This is encouraging illegal trading of minerals. These traders are not only doing illegal mining and transport but also helping China to prosper by exporting iron ore, manganese ore and chromite, who is a competitor with India in economic growth in international level. It is pertinent to mention here that in spite of debates and alertness regarding mining scam for the last six months, during the month of January 61% of iron ore transported from Jaroli and Banspani Railway siding (125 out of 204 rakes) could not be identified regarding its source. Even though the State Govt. has issued notice to suspend mining operation in 165 mines within the last 6 months, the export of iron ore from Paradip Port has crossed its target during last month. The State Govt. should realize the gravity of the situation. On this issue, the Govt. should change its rules and objectives and curb illegal trading by cancelling these trading licenses immediately.

Fifthly, as the enquiry conducted by the Enforcement Squad of the Directorate of Mines has faced obstruction in some places, the State Vigilance Department is now functioning as a part of Directorate of Mines. Information has been received that the Vigilance Department is visiting mines without prior notice and requesting them to express their irregularities voluntarily. This is like beating about the bushes. It is high time that the Directorate of Mines should re-organise its Enforcement Squad. Being equipped with modern instruments, the mining, forest, environment protection and revenue officials may be posted under an Additional. Director of Mines. They may conduct enquiry in working mines and identify the scam and irregularities. They may conduct raid in illegal mines outside the mining lease areas and stop their activities. The State Govt may conduct enquiry through Vigilance or

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CBI or National Investigation Agency on the mining scam related information like that of M/s Ram Bahadur Thakur and take strong steps, but it will be wise if the Central Govt. controls the irregularities in working mines through the prevailing rules and regulations.

Sixthly, based on the information of the Ministry of Mines, 28,079 illegal mining activities in Andhra Pradesh, 23,220 in Gujurat, 14,615 in Maharastra, 12,526 in Madhya Pradesh, 11,204 in Jharkhand, 6,325 in Chhatisgarh, 6,883 in Karnataka, 6,802 in Rajasthan and 1,998 in Odisha have been identified during last 3 years (2006-2008). In spite of increase in the no. of mines in the country and rise in irregularities in the mines, the manpower strength of 'Indian Bureau of Mines', constituted for mining, development and conservation of minerals, have gone down by 40%. This is not an auspicious sign. The Central Govt. may re-constitute the Indian Bureau of Mines by filling the vacant posts through recruitment.

Seventhly, the most important is protection of the environment and its balance. Even though the development of mineral resources in our country is continuing unobstructed, lack of balance is observed between mining industrialization and the environment. Due to environmental imbalance, there has been global warming and unnatural changes in the climate. In view of that the drive for reduction of carbon dioxide in the mines and environmental conservation has a new objective. Therefore, the Govt. of India should form "Indian Environment Bureau" in the style of the "Indian Bureau of Mines" and work dedicatedly to conserve environment in the mines and other industries through existing rules and regulations. The Ministry of Forest and Environment, Govt. of India is welcome to take required steps on the matter.

At last, in spite of whatever steps to be taken, it is not possible to bring transparency in mine industrialization without active and positive co-operation of the mine owners. To have a transparent mining project, change in the mentality of the mine owners is absolutely necessary. The officials working in the mines and the mining advisors have a major role in changing the mentality of the mine owners. So it is desirable that they should make sincere efforts on the matter. If the mine owners get determined to have transparent mining projects, there is no doubt that the mining scam will come to an end automatically.

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IS AUCTION MECHANISM FOR ALLOCATION OF MINERAL RESOURCES PROPER?

The Industrial Policy Resolution adopted in 1956 for Industrial development in the country also resoluted mineral policy, which envisaged grant of Mineral Concessions on "First Come First Serve" basis for mineral development. The policy was reflected in Section 11 (2) of Mines and Minerals Development and Regulation Act, 1957, and Rules there under. Since then mineral concession like PL, ML and more recently for exploration and mining of metallic and non metallic minerals in our Country are being granted to applicants on "First Come First Serve" basis.

In a significant development, the Supreme Court of India on 2nd February 2012 on a verdict of 2G spectrum scam, while canceling 122 2G spectrum licenses awarded to different companies on the basis of "First Come First Serve" principle, also held that public trust doctrine warrants auction route to be the sole method of distribution of all natural resources of the country. In view of the fact, there are established law of the land for allocation of natural resources for its development, the Govt. of India on 2nd April, 2012 has made a Presidential reference to the apex court seeking its opinion whether auction route will be mandatory for allocation of all natural resources of the country, including mineral resources.

In the meantime, there has been a rethinking by the Hon'ble Supreme Court on policy of auction route for distribution of natural resources. In a verdict on 2G spectrum scam, the Constitution Bench of the Supreme Court on 10th July, 2012 consisting of Chief Justice H.S. Kapadia, Justice D.K. Jain, Justice J.M. Khelar, Justice Deepak Mishra and Justice Ranjan Gogol upheld the cancellation of 122 2G spectrum licenses, but agreed to examine the reservation of Central Govt. on allocation of all natural resources by auction route. Similarly on 1st August, 2012 on 2G spectrum scam, the Hon'ble Supreme Court observed that the "First Come First Serve" policy is fine, but there was flawed application in allotment of 2G spectrum licenses in 2008. Therefore, it is not certain whether the policy of auction route for allocation of mineral resources will be favoured by the Apex Court.

In case the Apex Court takes a decision for allocation of mineral resources by auction, it will not be smooth on the part of the Centre and the State to enforce this policy in near future due to the following five reasons:

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Firstly, the Govt. of India has to convert the policy to law by way of amending section 11 (2) of MM (D&R) Act, 1957, which is a time consuming process. For example, amendment of MM (D&R) Act, 1957 to introduce auction procedure for allotment of coal blocks although initiated in 2005, the Government has not finalized its modus operandi as on 2012.

Secondly, the State Government has to mobilize its resources to undertake detailed exploration of free mineralized deposits of the State for assessing reserve and grade of minerals vested in the area to be auctioned. Besides, the reserve price of a mining lease area does not solely depend upon reserves and grade of minerals, but also largely depends upon the implementation of cost intensive mining geological, socio-economic and environmental parameters, without which the State can not arrive at its reserve price to facilitate auction.

Thirdly, the State Govt. has to prepare a due diligence report on each ML area to be auctioned by a renowned independent agency acceptable to the bidders. The completion of these processes, even on crash programme basis, will take minimum a decade for the Govt. to initiate auction in allocating mining blocks which will no dobut retard the growth of mineral industry in the country.

Fourthly, in 1991, like coal, Govt. of Odisha suddenly realized that working of gemstone by the state owned organization is not remunerative and decided to auction gem rich blocks by competitive bidding. The state Government identified 12 such blocks for aquamarine and sapphire in Bolangir and Kalahandi Districts for a reserve price of Rs.20 lakhs, and could auction only 5 such blocks for Rs.22 lakhs, but the leased out areas could not be worked subsequently to fetch more revenue for the State. Taking the clue from Odisha, the Government of Andhra Pradesh identified seven blocks of gemstones for auction at a reserve price of Rs.35/- lakhs, which fetched the State Rs. 5/- crores on auction, but more than decade have passed, the leases are not operated on date to fetch more revenue for the state. Therefore, it is evident that mechanism of auction is not conducive for mineral development and revenue earning for the state.

Lastly, the Apex Court in their order of 2nd February, 2012 observed that while allocating the natural resources on auction route, the doctrine of public interest, has to be adhered to which is not possible if the country adopts the auction route. For example, if we auction fish resources of Bay of Bengal, the Japanese Trawler Companies may bid highest price, but the livelihood of the East Coast fishermen will be in

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jeopardy. Similarly when we auction mining blocks, the multinational companies may bid highest price, but it may not be feasible to work the mining lease like Niyamgiri bauxite mining project of Odisha in the midst of conflicting interest with local tribes. Recently, as the Central Govt. has kept a reserve price of Rs.14000 crore for auction of 2G spectrum, it is apprehended whether a common man can use a mobile phone at the rate of 30 paise which is against the principle of the Hon'ble Supreme Court by contradicting the doctrine of public interest. It is said that 85% of the power tariff is ascribed to the cost of coal. Recently the power tariff in different states were enhanced due to the rise in the cost of coal. The state governments were compelled to do this. The CAG report on 17th August, 2012 suggest for allocation of captive coal blocks to private sector companies for feeding infrastructure industries by competitive bidding, which may bring substantial revenue to the exchequer and transparency in the system; but eventually shall transfer cost of auction value to the consumers. This will ultimately escalate the cost price of power, steel and cement to be borne by the consumers only, which undoubtedly contradicts the doctrine of public interest. Therefore, the auction route is not the possible alternative to "First Come First Serve Basis" policy for allocation of mineral resources.

At present the problem of mineral production and its utilization is more important than the problem of methods for allocation of mining resources. The development of mineral resources in the state has been hampered after mining scam in Odisha has came to limelight during 2010. Out of 602 mining leases in the state, only 112 leases are working. The production of minerals in the state has gone down beyond expectation. The production of iron ore was 79.65 million tonne during 2009-10, 81.14 million tonne during 2010-11 and gone down to 60.62 million tonne during 2011-12. The status of production of other minerals in the state is also similar. On observing the status of grant of mining leases, it is seen that more than 4917 applications are pending with collectors, 484 with the Director of Mines and 756 with the Department of Steel & Mines for recommendation. This is indirectly encouraging illegal mining. To meet the demand for power, steel and cement, 57 mining blocks for coal have been allocated during 2006-09, but for want of various clearances none of the coal mine has become workable.

The Prime Minister's Economic Advisory Council on 17th August 2012 has projected economic growth for our country to be 5.3% in industrial sector, 4.4% in mining sector and 6.7% in GDP in this fiscal year. This is dependent on mineral production and growth of mineral industries in the country. Therefore fastening the

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process of mineral utilization is more important than allocation of mining blocks through auction.

The mineral wealth of the country belongs to people of India and its law for utilization has to be people centric. Concurrently, the Central Government has tried to make law more people centric and brought MM (D&R) Amendment Bill 2011 in the Parliament protecting the interest of common men, which is largely in consonance with the doctrine of public interest. The act envisages the royalty and dead rent sharing by the tenants in the mining lease and share of profit/ royalty available from mining of coal and other minerals for local area development, which are well reflected in Section 25(1)O, 25(1)P, 37 and 43 (2) of MM (D&R) Amendment Bill 2011 waiting for clearance of the Standing Committee and once the bill is passed by the Parliament, will no doubt encourage hastlefree development of mineral resources in the country.

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TECHNO ECONOMICS OF COAL BLOCK SCAM

The Ministry of Coal (MOC) has allocated 57 Captive Coal blocks to private Companies (2006-2009), 55 to meet the growing demand of Coal for Core Sector Industries like Cement, Power and Steel and 2 blocks for conversion of Coal to Liquid (CTL). The MOC has allotted 9 such blocks in Odisha, 26 in Jharkhand, 3 in West Bengal, 4 in Maharashtra, 13 in Chhattisgarh and 2 in Madhya Pradesh. The CAG has observed that allocating these blocks to private companies by nomination rather than by competitive bidding has benefited windfall gain Rs. 1.86 lakhs crores to these private players. The hypothesis of CAG assumes that these Coal blocks when mined to the critical depth of opencast mine limit and sold in the market by these companies will earn the profit of Rs. 1.86 lakh crores. If these blocks could have been allotted by competitive bidding, the Government could earn some revenue from the gain. The CAG has assessed the profit to the private companies based on difference of the average cost of production and average sale price of Coal India (CIL) Mines (Rs. 295.41/tonne), multiplied by the total Extractable Coal Reserves of 6282 million tones contained in 57 Coal blocks. The parameters based on which these assessment have been done appears flawed due to following five reasons;

Firstly, in view of the growing demand of the Coal in the Country, the mechanism of captive source of Coal to be developed by private companies for sustained supply to Core sector industries of Steel, Cement and Power has been evolved to supplement the Coal India production. In this captive mines there is no scope of producing and selling Coal to earn profit. The production cost of the captive mines is directly charged to the cost of end products on cost to cost basis. Therefore, these 57 captive Coal blocks are not comparable with the CIL mines poised for commercial mining with profit making objective.

Secondly, the Extractable Coal reserves in 57 blocks have been estimated by CAG as 6282 million tonnes, which also include two blocks of coal, containing 1650 million tonnes of subgrade coal having more than 45% ash content and not comparable with marketable and profit earning E, F & G grade coal deposits of CIL. These blocks are one at North Arakhpal containing 1095 million tonnes allotted to Strategic Energy Technology Systems, a TATA-ASOI Joint Venture Company and another at Ramachandi containing 555 million tones allotted to Jindal Steel & Power Ltd. In Talchir coalfield of Odisha for promotion of Coal to Liquid (CTL) Industries. Therefore there is scope for reducing 1650 million tonnes from the total Extractable reserves of 6282 million tonnes assessed by CAG.

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Thirdly, the cost of production of a Coal mines basically depends upon its mining geological parameters, such as Coal : over burden (OB) ratio, which varies from mine to mine. The average Coal : OB ratio of CIL mines will be 1:2.5, whereas the average Coal : OB ratio of Coal blocks under consideration will be minimum 1:6. The cost component of removal of overburden in CIL mines at the rate of Rs. 80/- per m3 will be Rs. 200/- per tonne, whereas as that of 57 blocks will be Rs. 480/- per tonne and hence enhance the cost of production and reduces the profit margin by Rs. 280/- per tonne.

Fourthly, the Supreme Court on 2nd February, 2012 in a landmark judgement on 2G scam, has held that allocation of all natural resources are to be done by auction, instead of "First Come First Serve' basis, but also emphasized that the doctrine of public interest has to be kept in view; while allocating such resources. The Govt. of India has concurrently moved a bill to amend MM (D&R) Act, 1957, which is people centric and pending clearance of the standing committee to be passed in the Parliament. The Section 43,(2) of the Act envisages that 26% of the profit of the Mines has to be appropriated to Government for local area development, which vindicates the concept of public interest. The cost component per tonne of Coal on this score shall be Rs. 76.80 for tonne on a profit margin of Rs. 295.41 / tonne, which has not been considered by CAG.

Lastly, the visible omission is the cost of Mine Closure Plan in evaluation of cost of production in CIL coal mines. The cost of Mine Closure Plan, which involves cost intensive reclamation plan has been introduced in the Mining Plan since 2009, has to be accounted for to evaluate the cost of production of Coal mines which will be not less than Rs. 10/tonne.

Considering all these techno-economic factors the cost economics of the captive coal blocks may sustain loss rather than any windfall gain for which the whole nation is worried. CAG is worried that Government could not share some gain because these blocks were not allotted through auction.

But to commence the auction process, it is essential to fix the reserve price of each coal block, which will not only depend upon the reserve and grade of Coal, and coal overburden ratio, but also on the cost element of forest conservation, environmental management, land acquisition, reclamation and resettlement of displaced persons, wildlife management and mine closure plan, which has to be critically evaluated. In order to assess the reserve and grade of coal block By USIS

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norm, it is essential to explore the deposit optimally by core drilling, which will take minimum ten years to complete spending may be ten thousand crores. As against that the country may get as fraction of this cost of exploration as a revenue from the auction. The auction allocation may yield some revenue for the Government and bring transparency in the system but the cost of auction has to be transferred and reflected in the cost of end products escalating the price of steel, cement and power.

Keeping all these in view, the allocation of mineral resources by auction is not a rational alternative to "First Come First Serve Policy". The issue of governance deficit to achieve objectivity and transparency in the existing process can be addressed but for a policy shift, there should be a national debate before taking any decision in this direction.

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NIYAMGIRI AND VEDANTA

During the last 5 years, there has been lot of discussions, reviews and criticisms on the mining project going to be set up in Niyamgiri hill of Kalahandi district. This ML is owned by the Odisha Mining Corporation and there is proposal of developing a mine having a production capacity of 3 miillion tonnes of bauxite per annum. Even though the proposal of handing over this mining lease to an independent organization managed by. M/s Sterelite Industry India Ltd has been rejected by the Hon'ble High Court of Odisha, it is being discussed as mines of Vedanta in the national level, Odisha Assembly or in news papers. Considering the coming up of a mining project of Vedanta ignoring the problems and culture of Dangaria Kandha, the local tribes, recently the British govt. has brought this discussion into international level. That is why I feel it proper to place before you the back ground behind Niyamgiri Mining Project and its present status.

The aluminium production in India had a low profile up to late 70s., which remained at 2 lakh tonnes per annum due to the constraint of limited resources of metallurgical grade bauxite in the country. The discovery of East Coast bauxite deposits in Odisha and Andhra Pradesh and the implementation of a crash programme of detailed evaluation of bauxite deposits in 1976-80, known as East Coast Bauxite Project (ECBP), augmented the metallurgical grade bauxite reserves to 2462 million tonnes occupying 5th position in the world, Odisha having the major chunk of 1730 million tonnes.

At that time the National Alumunium Company has achieved international reputation in the market by producing alumina at Damanjodi utilizing Pachpatmali bauxite and producing aluminium at Angul. The success story of NALCO and adoption of liberalized National Mineral Policy by Govt. of India in 1993, attracted the Indian and Foreign Aluminium Companies, who visited Odisha and showed keen interest to set up green field Alumina Projects in the State based on East Coast bauxite deposits and had an eye for covering bauxite deposits under mining lease as captive mines. At such a juncture, I as General Manager (Geology) of OMC suggested the then CMD, Sri U.S. Bhatia to cover all the potential bauxite deposits of the state under mining lease, who appreciated my vision and we applied Mining Lease for Baphilimali & Pottangi bauxite deposits in Koraput district and Lanjigarh & Karlapat bauxite deposits in Kalahandi district. As a result all potential deposits were held by OMC.

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Being unsuccessful in getting mining leases, the Aluminium Companies, without wasting any time, motivated the State Govt to take decision in principle in respect of proposed alumina industries and the bauxite deposits to be linked to it. The State Govt. identified bauxite deposits on 21st January, 1997 to be linked as captive mines to alumina industries proposed to be set up by 7 Aluminium Companies in the State. As a result Panchpatmali for NALCO, Kodingamali and Pottangi for HINDALCO, Lanjigarh and Karlapat for Sterelite Industry India Pvt Ltd, Baphilimali for Indian Aluminium, Gandhamardan for Continental Resources, Sasbohumali-Passangmali for PT Indorama and Kutrumali-Sijamali for LARSEN & TOURBRO were tied up as per the linkage policy of the State Govt. Based on this decision, Sri Anil Agrawal, the Industrialist, first prepared a plan for setting up of a alumina plant at Lanjigarh by M/s Sterelite Industries India Ltd., an Indian Company, utilizing the bauxite of Lanjigarh and Karlapat. As per directive of the State Govt., the Odisha Mining Corporation first signed an MOU with M/s Sterelite Industry India Ltd on 27th April, 1997 for a bauxite mining project at Lanjigarh. Later on in 2003, M/s Vedanta Resources PLC, London, the parent company of Sri Agrawal, after taking a decision for setting up of an alumina plant at Lanjigarh by M/s Vedanta Alumina Ltd. in place of M/s Sterlite Industries India Ltd, sent a proposal to the Govt. of Odisha. Agreeing to this proposal, the Govt of Orissa directed OMC to sign an agreement with M/s Vedanta Alumina Ltd for this project. OMC signed agreement with M/s Vedanta Alumina Ltd on 4th October, 2004. In this agreement, there was provision of production of 3 million tonnes of bauxite per annum from Niyamgiri by a joint venture company set up by OMC and M/s Vedanta Alumina Ltd for supply to the alumina plant at Lanjigarh.

In that year, in the winter session of the Assembly, the opposition protested against this agreement showing heavy loss to be incurred by the State and OMC and demanded to cancel it. As a result pandemonium was created in the Assembly frequently and the function of the house was adjourned for days together and the project remained as such.

Out of 721.327 Hects of area of Niyamgiri Mining Lease, there is 660.749 Hects. of forest land. For utilization of this forest land for mining purpose, the Odisha mining Corporation applied to the Ministry of Forest and Environment as per Forest Conservation Act, 1980 for approval. There is provision of sending this proposal to the Empowered Committee of the Hon'ble High Court for consideration. At that time the Wild Life Society of Odisha, Bhubaneswar, Loka Abhijana of Berhampur, Environic Trust of Dehradoon and the NGOs connected with environment applied to

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the Hon'ble Supreme Court for not to grant forest and environment clearance to this mining project apprehending environmental degradation including destruction of shrines and culture of Dangaria Kandha if mining operation is done at Niyamgiri. As a result, the Central Empowered Committee of the Supreme Court visited Lanjigarh on 14th and 15th June, 2005 to look into the problems and submitted their opinion. Taking into account all information received, the Hon'ble high Court took a decision that M/s Vedanta Alumina Ltd cannot work with the Govt. and Govt. organization like OMC on commercial basis; as M/s Vedanta Resources PLC, its parent company, was blamed by the Govt. of Norway. In this decision the Hon'ble High Court directed OMC to mine bauxite jointly with the Indian M/s Sterelite Industry India Ltd.

Mineral resources are national properties but environment is both national and international. Even though industrialization and development are continuing uninterruptedly in the country, lack of balance is observed between development and environment. Due to environmental imbalance, there has been global warming and unnatural changes in the climate which is a challenge for the humanity. Therefore, in any industrialization, it is necessary to give importance on conservation of environment and control of pollution. So in Niyamgiri project, conservation of environment alongwith that of minerals is important. In view of all these problems, the Hon'ble High Court, for keeping a balance between Niyamgiri Mining Project, Alumina Industry at Lanjigarh and environment, entrusted the work of peripheral development and protection of environment within an area of 50Km radius to a special organization set up by the Govt. of Odisha, the Odisha Mining Corporation and M/s Sterlite Industries India Ltd. As a result M/s Vedant Alumina Ltd has been deprived of the involvement in the programme of environmental protection in this industrialization. Sri Agrawal, the Industrialist, in order to attract the feelings of Indians with Vedic philosophy, framed a company in the name of M/s Vedanta Alumina Ltd. instead of M/s Sterelite Industry India Ltd and took an attempt for setting up of an alumina project in Odisha. It is worth mentioning that Jagatguru Sankaracharya, in first decade of 18th century, had explained the basic-concept of Vedic philosophy through Gita and Upanishada. The main objective of Vedic philosophy is to feel divine presence in all, both living and non-living and to create peace, harmony and fraternity; but the M/s Vedanta Alumina Ltd. has failed to establish the basic concept of Vedic philosophy neither in case of Niyamgiri bauxite mines nor alumina plant at Lanjigarh. It was seen in the BBC channel on 27th July that M/S Church of England & Middlebro Council (share holders of Vedanta Resources PLC), great personalities

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like Arundhati Ray of India, Biyanka Jagar of London and Sitaram, a Dangaria Kandha youth of Niyamgiri were staging a protest outside the annual general meeting of M/s Vedanta Resources PLC. It is known from the above that the M/s Vedant Alumina Ltd has failed to establish peace, harmony and fraternity on the basis of Vedic philosophy. The Hon'ble High Court, understanding this philosophy, has perhaps felt it proper to keep M/s Vedanta Alumina Ltd. outside Niyamgiri.

Besides Vedant has also been criticized despite its effort to set up Vedanta University in Odisha for promoting quality education. The Harvard University of the USA is the best university of the world. This university has been established over an area of 384 Acres out of 4985 Acres of campus; where as in a country like India where the per capita land is the lowest, establishment of the Vedanta University over an area of 6000 Acres is going against social values. So it is apprehended that many obstacles may arise if the project is not worked out on the basis of the basic-concept of Vedic Philosophy. Therefore, it is discussed in the public that Anil Agrawal, the Industialist should review all the Vedant projects coming up in the country.

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OMC-VEDANTA MINING DEAL- A NON ISSUE

The statement of Srikanta Jena, Former Union Minister of Parliamentary Affairs, who has requested the Chief Minister of Odisha to scrap the agreement reached between the Odisha Mining Corporation (OMC) and Vedanta Alumina Limited (VAL) for mining Lanjigarh bauxite deposit and supplying to the VAL for their 1 MTPA capacity Alumina Plant at Lanjigarh and reaction of Shri Padmanav Behera, the Minister of Steel & Mines, Odisha defending the action of the state and OMC has not only sparkled a controversy, but also aroused misgivings in the minds of the people. If I remember correctly, this issue rocked winter session of Odisha Assembly in 2004 stalling many Assembly hours and now heading towards a lingering controversy which needs to be addressed. Both the statesmen no doubt have visions and concerns for the economic growth of the state and therefore their concern for a transparent Mining Project in the state is imaginable and needs to be clarified.

The aluminium production in India had a low profile up to late 70s., which remained at 0.2 MTPA due to the constraint of limit resources of metallurgical grade bauxite in the country, which was hardly around 200 million tones. The discovery of East Coast bauxite deposits in Odisha and Andhra Pradesh and the implementation of a crash programme of detailed evaluation of bauxite deposits in 1976-80, known as East Coast Bauxite Project (ECBP), augmented the metallurgical grade bauxite reserves to 2462 million tones occupying 5th position in the world, Odisha having the major chunk of 1730 million tonnes.

Based on detailed exploration of bauxite deposit in Panchpatmalli in Koraput district of Odisha, one of the largest single bauxite deposit of the world, National Aluminium Company Ltd (NALCO) developed a mechanized opencast mine for an annual production of 2.4 MTPA, supposed to be the largest opencast mine in the South East Asia, for production of 0.8 MTPA of alumina at its refinery at Damanjodi and 0.218 MTPA aluminium at its smelter at Angul. NALCO started production in 1987-88 and immediately started export of surplus alumina and metal and earned International recognition due to its quality and cost competitiveness. The success story of NALCO and adoption of liberalized National Mineral Policy by Govt. of India in 1993, attracted the Indian and Foreign Aluminium Companies, who visited Odisha and showed keen interest to set up green field Alumina Projects in the State based on East Coast bauxite deposits and had an eye for covering bauxite deposits under mining lease as captive mines. At such a juncture, I as General Manager (Geology)

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of OMC suggested the then CMD, U.S. Bhatia to cover all the potential bauxite deposits of the state under mining lease, who appreciated my vision and we covered Baphilimali, Pottangi, Laniigarh, Karlapat bauxite deposits for mineral concession, besides Gandhamardan and Kodingamali deposits, which were applied earlier. These deposits were to be exploited by OMC to feed the upcoming alumina plants in the State.

Due to lobbying by the Aluminum Companies, the Govt. of Odisha toyed with a concept of captive mines for alumina plants and tied up different bauxite deposits of the state with different brownfield and greenfield alumina projects, like Panchpatmali for NALCO, Kodingamali and Pottangi for HINDALCO, Lanjigarh and Karlapat for Sterlite Industries India Limited, Gandhamardan for Continental Resources, Sasbohumali-Passangmali for PT Indorama, Kutrumali-Sijamali for LARSEN & TOURBRO and Baphilimali for INDAL, as per the linkage policy of the State Govt.

As per the directive of the State, OMC signed an agreement with INDAL on 18.2.1983 for development of Baphilimali bauxite deposit which envisages;

(i) Transfer of the mining lease of Baphilimali by OMC to the export oriented 1 MTPA capacity Alumina plant to be set up by its Company at Kasipur in Rayagada district.

(ii) In lieu thereof OMC shall have fully convertible preferential share in the said Company to a tune of Rs.20.00 Crores, 15% of which will be paid by the company to OMC for 10 years, which amounts to Rs.30.00 crores.

As a result the mining lease of Baphilimali was transferred to Utkal Alumina International Limited (UAIL) on 10.11.2000, a leasehold having 200 million tones of bauxite at a throw away price of Rs. 1.50 per tone. Whoever may be in the background of decision making, the deal certainly lacked vision for which OMC has sustained colossal loss of revenue and now OMC should move to the State Govt. to revert back the mining lease.

The Sterelite Industries India Ltd. was also on the fray to set up an Alumina Plant in the state. Likewise as per the directive of the Govt. of Odisha, OMC entered with an MoU with M/s. Sterlite Industries India Limited on 3rd April, 1997 which envisages;

(i) Transfer of the mining lease of Lanjigarh & Karlapat by OMC to their company to set up an Alumina Plant at Lanjigarh

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(ii) In lieu thereof OMC will be paid by the company 50% of the royalty per tonne of bauxite to be used for production of aluminium and 100% of royalty per tone of bauxite to be used for alumina plant. In case of enhancement of royalty, the State Govt. will get the enhanced royalty, but not OMC.

But, OMC reviewed its MoU and with the approval of the State Government entered with an agreement with Vedanta Alumina Limited (VAL) in 5th October, 2004, which envisages;

(i) Mining leases will not be transferred to the VAL and shall be worked by OMC

(ii) OMC & VAL will form a JVC to develop and produce 3 MTPA of bauxite from Lanjigarh and other deposit to be granted by State Govt. to OMC, as a raising contractor of OMC, in which OMC will hold 26% free equity.

(iii) OMC will sale bauxite to VAL on payment of raising cost, equal amount of royalty as consideration money to OMC, royalty and 12% VAT to the State Govt. per tone of bauxite sold to VAL.

The issue revolves round the sale price of bauxite in the agreement which is said to be conducive for sustainable loss for the state obviously for OMC as a Lessee. Therefore, the issue of price of bauxite for the Alumina Project needs to be focused. It is alleged that bauxite being sold for Rs.2250/- per tone in International market, why this could not be sold to VAL at least for Rs.500/- per tone. From India much higher grade bauxite is being exported from Gujurat for little less than FOB $ 18 which comes to only Rs.800/- per tone. But basically the export price of bauxite has no relevance to the price of Lanjigarh bauxite for VAL for the simple reason that in case of export you get one time price, whereas, in case of Lanjigarh bauxite being sold to VAL, shall have value addition producing alumina for export. This will not only yield export earning to VAL but also accrue custom duty and port charges to the Govt. of India.

Besides, in a green field Alumina project having production of 1 MTPA for which 3 million tonne bauxite is needed, there is an optimal cost of bauxite provided in the project cost which is maximum Rs.350/- per tone to make alumina viable and cost competitive. The transferred cost of bauxite for NALCO Project is Rs.212 per tone, for INDAL, Belgaon Rs.216/- tone and where as the cost of bauxite for other Greenfield alumina projects may vary from Rs.250 to 350 per tone depending upon logistics. Therefore, the suggestion of sale of bauxite for Rs.500 per tone for the proposed Alumina plant is not a feasible proposition and hence becomes a non starter for the project.

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Let us analyse who looses and who gains from this deal at a production and sale level of 3 MTPA of bauxite to VAL.

(i) The State Govt. realized to Rs. 18 crores as royalty and Rs.11.52 crores as VAT per annum is more than it earns from Panchapatmali bauxite Mines of NALCO and does not sustain any loss.

(ii) After meeting the statutory dues to the State Govt. OMC earns Rs.18.00 crores per annum plus 26% dividend from its JVC with zero investment, which is precisely the corporate profit of OMC for 2002-03.

(iii) OMC-Vedanta JVC being involved in mining operation of OMC shall have to give Service Tax to the State Govt.

(iv) Although OMC- Vedanta will be engaged for mining operation of the mines, OMC as Lessee have to manage the mines as per Act and Rules and to meet the statutory obligations, for which OMC may get a Management fees from VAL also.

(v) The Govt. of India earns custom duty from VAL for the export of alumina to the oversea buyers and the exporting port get their port charges.

The OMC has learnt from its mistakes committed from the earlier deal with INDAL and has taken a prudent step in entering such an agreement with VAL which no doubt is a welcome development. The deal looks transparent, which not only safeguards the interest of the state adequately but also enhances the corporate profit with zero investment, which could be utilized for diversification in other projects of the corporation. In view of this, neither OMC nor the State sustains any loss and for that matter does not attract any issue.

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A NATIONAL POLICY OUTLOOK FOR GEM MINING IN INDIA

1.0. INTRODUCTION

1.1. India is known for exploitation of gemstones like Diamond, Ruby, Emerald, Sapphire, Alexandrite, Chrysoberyl cat's eye. Aquamarine, Iolite, Garnet, Tourmaline, Zircon, Topaz etc. since ancient times. The famous Indian diamonds like the Kohinoor, the Regent, the Orlov, the Hope, the Great Moghul and the Dresden Green have been won from India. India being the pioneer nation in the world for winning diamond, the history of diamond mining can be traced back to 500 B.C. In 330 B.C., the Kautilya, the Pioneer Mineral Economist of the world in his treatise on Arthashashtra has not only advised Emperor Chandragupta Maurya to dig for diamond around the diamond prospects of the country, when he is short of resources, but also outlined the guidelines to collect revenue when the diamond is mined and sold in the country. The Ratnapariskhya of Budhabhatta in 5th Centrury AD and Brihatsamhita of Varahamihira of 6th centrury AD have outlined the criteria of evaluation of diamond based on its form, optical properties and extreme rarity. The diamond mining in India was significant from 16th to 18th century where mining was going on in Golconda, Kollur, Ellur and Cuddapah in Andhra Pradesh and Sambalpur in Odisha and Majhagawn in Madhya Pradesh. India in that period continued to be the largest supplier of diamond in the world market until middle of the Eighteenth Century, when Brazillian diamond came to market. Similarly the coloured gemstones mined from Odisha, Rajasthan, Andhra Pradesh, Karnataka, Tamilnadu, Madhya Pradesh and Kashmir have enriched Jaipur as one of the largest fashioning centre in the world for coloured gems.

1.2. The export revenue of Gem and Jewellery industry in India attained $ 12 billion in in 2003-04 and poised to attain $ 16 billion by 2006-07, out of which only 20% are from coloured gemstones. The gemstones like Emerald, Ruby, Sapphire, Aquamarine, Tourmaline, Iolite, Chrysoberyl Cat's Eye, Garnet, Topaz, Peridot, Lapis Lazuli, are imported from Latin American and Afro Asian countries. Although there is ample scope of boosting export of cut and polished gemstone and studded jewellery from our Country, there is constraint of indigenous gemstone roughs. Therefore, there is need to create a conducive environment

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for mining coloured gemstones in India by adopting an apt mining technology and evolving a suitable policy for gem mining operation in India.

2.0 TECHNIQUES OF MINING:

2.1 The exploration of gemstone deposits largely depends on the geological milieu, type of gemstone, mode of occurrence, size of the deposit, depth of the deposit, reserve and grade of gemstones and available infrastructure. The gemstones in India occur in diverse geological milieu, the diamond in association with Kimberlite/ Lamphrolite, Ruby, Sapphire and Emerald with contact of pegmatite and Ultramafic rocks, High grade pelitic schists, Nepheline syenite, Anorthosite-Gabbro complexes, Cordierite-sillimanite garnet schists, Alexandrite and Cat's Eye varieties of Chrysoberyl in pegmatite/ ultramafic contact, Rhodolite garnet and Iolite in high grade pelitic schists. Most of the gemstones in India are concentrated in Archean granulite belt known as the Eastern Ghat granulite belt. The gemstones are mostly concentrated in the host rocks as eluvial deposits, as disseminated pockets and elongated veins. When reworked and transported, the gems are deposited as colluvial deposits and when further transported, deposited as gem gravel as alluvial deposits. The deposits are mostly small, sporadic and shallow in nature, which severally governs the techniques of exploitation to be pursued for the mining of the deposits.

2.2. The gem mining operation around the world, irrespective of their scale is done by mechanized mining operation and processing of the excavated gemmiferrous materials which involve:

- Excavation of pits, benches, shaft and tunnels in the host rocks,
- Excavation and transportation of host rocks by excavator and dumper combination,
- Use of scrubber and disintegrator for attritioning the ROM to liberate particles from the host rocks,
- Washing and pulping for making slurry of the disintegrated ROM,
- Screening the slurry to get the gemstone roughs,
- Jigging for concentrating gemstone roughs and eliminating tailings.
- Use of sorting conveyer and tables for manual sorting to recover gemstone roughs.

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These operations are done with tight security cover incurring high expenditure on security network. These gem mining operations require use of processing equipments, expertise and substantial high risk investment.

3.0 STATUS OF GEM MINING OPERATION IN INDIA:

3.1 In India barring underground mining operation for Emerald in Rajasthan, the mining operation are done mostly manually and predominantly by clandestine operation. On advent of rediscovery of gemstone in Odisha in late seventies, organized Opencast Exploratory mining operations were pursued in Damjhor and Siali- Naktamunda for garnet, Badmal and Sangamra for Aquamarine, Sirjapalli and Paika Dhakulguda for Chrysoberyl Cat's eye and San Irukubadi for Sillimanite Cat's Eye in 1982-90 by the Odisha Mining Corporation Ltd., a Govt. of Odisha Undertaking, in which cost of security was quite high because the scale of operation was meager. This has to be triggered by pursuing mechanized mining operation. In different gem bearing states, attempts have been made for systematic gem mining operation, the initial steps being grant of mining lease for exploitation of gemstones. The systematic mechanized mining operation for mining of gemstone is being pursued in Majhagawan pipe in Panna Diamond Mines of NMDC in Madhya Pradesh and Jillingdhar Ruby mines of OMC in Odisha, both in public sector.

3.2 In view of the nature of Indian gemstone deposits, it is not only essential to adopt suitable method for mining operation for winning the gemstones quickly to avoid heavy expenditure on security cover of the mine, but also desirable for fixing suitable agency for proper exploration, exploitation and utilization and conservation of gemstones. This paper depicts various options of working of gemstone, by public sector, joint sector and private sector agencies with a view to fix perspective option for meaningful exploration and exploitation of gemstone resources of our country.

4.0 WORKING OF GEMSTONE BY PUBLIC SECTOR:

4.1 Gem Policy:

On October 31, 1981, the Government of Odisha, the leading gem bearing state of our country, made a policy resolution and notified a policy of exploration and exploitation of Precious and Semiprecious stones by the Odisha Mining Corporation Limited (OMC), a public sector undertaking in gem rich districts of

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the state as an agent of the State Govt. The terms of reference for working of gem stone by OMC was as follows:

(i) To undertake exploration of precious and semiprecious stones.

(ii) To undertake exploratory mining of precious and semiprecious stones.

(iii) To purchase gemstone from diggers those who collect gemstone from the private and Government land.

(iv) To retain the stock of gemstone collected from exploration, exploitation and purchase of gemstone in safe custody and selling the stock of gemstone by public auction.

(v) In case the operation ends in surplus for OMC, a part of surplus shall accrue to the state government and in case of eventual loss, the question of compensating the loss of OMC, wholly or partially, will be considered by the government.

4.2 Exploration:

With the above objectives in view, the Odisha Mining Corporation Ltd, pursued exploration by geological mapping, trenching, pitting and washing of heavy minerals in different gemmiferous belts of Kalahandi, Sambalpur, Bolangir and Rayagada districts and identified different mineable blocks for exploratory mining of gemstones. OMC assigned late M.N. Vishwanatha, Gemmological Consultant for appraisal of gembelts identified by OMC, who after due appraisal recommended 7 potential belts in Kalahandi district and 9 potential belts in the rest for detailed exploration. Besides, Dr. Jan Kanis and Dr. J.L.S. Gracia, Gemmologists of International repute, also visited Bolangir and Kalahandi districts of Odisha as per request of OMC and made an appraisal of the colluvial, alluvial and eluvial gem deposits and suggested for exploration and exploratory mining activities.

In the block period of 1982-90, the exploration input by OMC are as follows:

(i) Delineation of 20 gem belts in six districts of the state for pursuing exploration.

(ii) Identification of 9 gemmiferous blocks for detailed exploration for Iolite, Garnet, Aquamarine, Alexandrite and Sapphire in Bolangir, Kalahandi and Sambalpur districts.

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(iii) Demarcation of three mineable blocks at Jillingdhar (Ruby), Budhapada (Rhodolite garnet) and Hinjilibahal (Ruby) by detailed exploration resulting in assessment of reserve of gemstones and preparation/ approval of mining plan for grant of mining lease in order to take up mechanized mining and washing for production of gemstones. This was a major contribution in the history of gemstone mining in the country.

4.3. Exploratory mining:

OMC pursued exploratory mining in Damjhor (Garnet), in Kalahandi district, Sangamra (Aquamarine) and Badmal (Aquamarine) in Bolangir district and Jillingdhar (Ruby) in Kalahandi district. The mining operation was basically carried out by semi mechanized operation in absence of proper process equipments and with tight security cover and produced 7,04,306 grams of gems including 1,31,993 grams of Aquamarine, 5,44,275 grams of garnet and 28,837 grams of ruby etc.

4.4. Purchase of Gemstone:

For procurement of gemstone, 9 purchase centers were organized by OMC in various gem belts of Bolangir, Kalahandi, Sambalpur, Rayagada and Phulbani districts. The gemstones were purchased from the diggers by a purchase Committee associating an experienced evaluator, after initial guidance by the Hindustan Diamond Company and Gem and Jewellery Export Promotion Council, Mumbai. OMC procured 1,32,25,052 grams of gemstone including 1,22,527 grams of Aquamarine 21,518 grams of Ruby, 1,29,80,605 grams of garnet and 73,302 grams of Iolite etc.

4.5 Marketing of Gemstone by Public Auction:

The stock of gemstones mined and purchased was kept in safe custody in each point of inspection. OMC sold these gemstones by public auction. One experimental auction was organized at Jaipur in May, 1985 and another two public auctions were organized at Bhubaneswar in 1989 and 1990 in which both national and international bidders participated. Most of the gemstone roughs were sold by auction yielding remunerative price.

4.6. Promotion Lapidary Units:

OMC also promoted 6 lapidary units in the State for cutting and polishing of gemstone including three in Bhubaneswar by way of supplying gemstone roughs to these units. OMC encouraged promotion of a Training cum- production

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centre at Bhawanipatna by Odisha State Co-operative Handicraft Corporation Ltd and trained 150 artisans for cutting and polishing of gemstones to be eventually absorbed in the growing lapidary units of the state, besides producing value added cut stones and characterizing the lapidary grade of different gemstone deposits of the state.

4.7. **Profitability:** On the end of the block period of 1982-90, it was found that OMC in the gemstone sector had a turnover over of Rs.1.00 crore and obtained a surplus of Rs.20.00 lacs which was eventually remitted to Govt. of Odisha, thus making profit in the project. The Majhagawan pipe of Panna Diamond mines of National Mineral Development Corporation Ltd (A Govt. of India undertaking) in Madhya Pradesh is also being worked successfully in public sector.

5.0. WORKING OF GEMSTONE BY JOINT SECTOR:

5.1 At such a juncture, the Govt. of Odisha looked for speedy development of the gemstone resources of the State, introducing renowned private players having expertise in mining, processing and marketing of gemstones and having commitment for use of imported processing equipments being worked in the other part of the world for gem mining operation in Odisha. In pursuance with a joint sector agreement reached with the state Government and selected private entrepreneurs, OMC promoted a joint sector company in the name and style of the "Gem Corporation of Odisha Ltd" (GEMCO) to undertake mining operation in Jillingdhar (Ruby), Hinjilibahal (Ruby) and Budhapada (Garnet) Mining Leases of OMC and also to promote Lapidary units at Bhawanipatna and Bolangir for cutting and polishing of gemstones for value addition in a big way. The GEMCO organized a Lapidary unit at Bhawanipatna, which was subsequently discontinued. GEMCO has initiated mining operation in Jillingdhar Ruby mines since 1993, the only organized Mechanised Ruby mines of the country facing decade of destiny to be exploited fully.

5.2: The private collaborators of GEMCO, pleaded for greater autonomy in working of gemstone for which the equity participation in GEMCO was revised. OMC holding only 11% and the private collaborators holding 89% equity in the company, converting the status of the company from joint sector to Assisted sector. The state government revised Gem Policy on December 11,1991. The Govt. of Odisha although reserved the gemstone rich district of the state for exploration and exploitation by OMC under Rule 75 of Mineral Concession

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Rule, 1960, directed that the Mining lease granted to OMC for gemstone will be worked by OMC or GEMCO in Assisted sector only. As per this directive, the GEMCO is operating at Jillingdhar Ruby Mines since 1993 by deploying Mobile Processing Plant although the ruby reserve of that order could have been mined in five years. No lapidary units have been set up by them. They are yet to take up mining operation in Hinjilibahal and Budhapada as agreed by them. Therefore, no tangible development has been done by GEMCO in the field of gemstone in this state even in joint sector and assisted sector too.

6.0 WORKING OF GEMSTONE BY PRIVATE SECTOR:

6.1 In the same notification the Govt. of Odisha held that remaining gemstone areas of the district will be demarcated and auctioned by OMC to private sector mining entrepreneurs on basis of competitive bids. As a result, 12 blocks were notified and auctioned by OMC at a base price of Rs.20.00 lacs, out of which 5 blocks, one for Aquamarine in Bolangir district and four for Sapphire in Kalahandi district were taken on auction for Rs.22.00 lakhs. But no successful mining operations could be launched in these blocks due to lack of expertise and enterprise. On the other hand, this move by the State Govt. encouraged clandestine mining, procurement and lapidary activities in the State.

6.2. The Government of Andhra Pradesh taking clue from this policy, identified seven potential gem areas in the State and auctioned the same to private sector mining houses. The floor price for each block was Rs.5 lacks and as against a base price of Rs.35 lacs in seven blocks the Government earned a revenue of Rs.5 crores, which was no doubt remunerative. But the state Government later did not see whether these mining blocks were being worked as per the law of the land with due regard to mining, conservation, utilization and value addition of the gemstone.

7.0 JOINT VENTURE MINING OPERATION AS POSSIBLE OPTION FOR GEM MINING:

7.1 As per Dr. Jan Kanis, UNDP Consultant for state of Odisha, the state controlled gemstone mining operations in Tanzania, Myanmar, Russia and Mozambique have been a failure and gemstone industries run by private sector is Brazil, Thailand, South Africa etc. are running in profits. But the Indian experiences discussed above show that the state controlled OMC worked gemstone profitably inspite of their lack of exposure to gemstone industry earlier, whereas

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the private sector operators like GEMCO etc, were utter failure in spite of their international exposure in the field. Therefore, the best option for exploration, mining and marketing of gemstone in our country will be joint sector company formed with state mining corporation for investment, mining conservation, utilization and security point of view. India's annual mineral production today stood at Rs. 65,540 crores and contributed about 2% of the Gross Domestic Product (GDP), In order to boost this sector, Rs.4000 crores of Foreign Direct Investment (FDI) has been approved by Govt. of India for opening up the mining sector to private and foreign investment. Many foreign collaborations have shown interest for development of coloured gemstone deposits in our country, who should be roped in for joint venture operation in different states. The JVC should also be authorized to purhase gemstones from local diggers by organizing purchase centres in the gemmiferous belts of the state through a Purchase Committee assisted by experienced valuer in order to curb clandestine trade on gemstone.

7.2. The alternate modality of exploitation of gemstone could be giving mining lease to private sector entrepreneurs for production of gemstone roughs and also sale of gemstone produced from the mines though public sector gem corporation as practiced in Sri Lanka and Thailand. The working of gemstones envisages reserving exploration, exploitation and marketing of gemstones by the Public Sector Corporation. The Government/ Corporation grants blocks of Mining lease to private sector mine owners for exploitation of gemstone on payment of one time revenue, but no royalty. The miner takes NOC, from the land owner if lease vested in private land and obtain mining lease by the Govt. / Corporation as the case may be and undertake mining operation. The gemstone produced from the mine is sold through the corporation in a public notified auction. In this deal, 10% of the auction value is retained by the corporation and 90% of the sale proceeds is given to the miner. After completion of the mining operation, the lessee reclaim the excavated land and get refund of certain % of the revenue deposited with the Govt. The practice has been successful, where the deposits are basically alluvial, small and vested in private land as practiced in Sri Lanka and Thailand. It is essential for Government of India and Gem producing state to take a policy decision to form joint venture company in each gem producing state to undertake exploration, mining and marketing of gemstone leaving private sector to develop lapidary units for cutting and polishing for value addition and export.

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GEMSTONES OF ODISHA AND GLORIOUS CUTIRAL HERITAGE

During late seventies (1975 to 1980) of the last century, after publication in the media regarding illegal raising and trading of gemstones in the western districts of Odisha, the entire incidence came to lime light. There was criticism for loss of revenue to the State Govt. for crores of rupees by illegal mining and transportation of gemstones to outside states from the erstwhile Kalahandi, Balangir and Sambalpur districts of Odisha for trading. In 1977 as there was complain in a sitting of the Assembly regarding no action taken by the State Govt. for curbing such illegal activity spreading in western districts of Odisha. The then Chief Minister Sri Nilamani Routray directed the Chaiman, Odisha Mining Corporation to investigate the matter and submit a report. After making a visit to Balangir District and discussing with the Collector and other officials on the issue, Sri A.L. Nair, the then Chairman, OMC and Sri N.K. Das, the then Chief Geologist of OMC returned without getting information regarding illegal mining and trading of gemstones.

At that time the gemstones of Odisha had achieved reputation in international market. From this area, gemstones were transported via Kantabanji for trading in Jaipur and Mumbai. During 1980 a news came in BBC channel regarding selling of a piece of emerald from Guchhepara-Antarla area near Patnagarh in Balangir District at London at a price of Rs. 5 crores. The rhodolite garnet from Kalahandi was very much appreciated in the gem market at San Francisco after being cut and fashioned at Frankfurt. Based on the information given by media, the Geological Survey of India of Govt. of India and the Directorate of Mining and Geology of Govt. of Odisha have taken up exploration for gemstones and faced the anger of local people. Instead of helping the geologists during exploration for gemstones, the local people threw stones at them and took attempt to burn their tent. After finding no other way out, the State govt. entrusted the Odisha Mining Corporation with the work of exploration, exploitation and trading of gemstones in the State on 31st October, 1981. The work was entrusted to OMC first in Balangir and Dhenkanal District in 1981, then in Kalahandi District in 1982, in Phulbani District in 1988 and in Koraput District in 1990.

As Deputy Chief Geologists of OMC, the responsibility was given to me. In November, 1982 a Regional Office was opened at Balangir by OMC at the centre of

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gemstone bearing areas and the work of exploration, exploitation and collection of gemstones was taken up in a planned manner. On the other hand, the main objective of the State Govt. was to prevent illegal trading of gemstones. OMC prepared a plan for collection of gemstones by opening purchase centres in different districts. Prior to purchase, it was very important to properly evaluate gemstones. As the geologists of OMC did not have expertise in valuation of gemstones, OMC took the help of Sri Jai Kisan of Hindustan Diamond Company, Mumbai and Sri Nitin Pachchigar of the Gem & Jewellery Promotion Council and first opened a puchase centres in Tikirapar village in Balangir District of Odisha in 1983. OMC was able to purchase gemstones from local people with the help of Sri Nathia Patra, renowned gem trader of Tikirapara village. Subsequently illegal trading of gemstones was checked to some extent after OMC undertook purchase of gemstones by opening 6 purchase centres in Balangir, Sambalpur and Kalahandi districts through an expert committee. After occurrence of aquamarine in Sangamra village of Balangir District was discovered, OMC cordoned the area, deployed security guards and raised around 1 lakh grams of aquamarine. At that time production of rhodolite garnet from Damjhar village of Kalahandi district, aquamarine from Badmal village of Balangir district and rhodolite garnet from Mantritarai village of Kalahandi District were going on. In 1986, OMC assigned Sri M. N. Viswanath, renowned Gemmologist of India, for appraisal of gembelts identified by OMC in Kalahandi, Balangir, Sambalpur and Dhenkanal Districts of Odisha and prepare a plan for their exploitation. Sri Viswanath made appraisal of the gem belts in the Kalahandi District in the first phase and Balangir, Sambalpur & Dhenkanal districts in the second phage, identified 16 tracts of occurrence of ruby, iolite, blue sapphire, chrysoberyl cat's eye, garnet, aquamarine a& alexandrite and recommended in April, 1987 for their development and exploitation. Besides, Dr. Jan Kanis and Dr. J.L.S. Gracia, Gemmologists of International repute, also visited Bolangir and Kalahandi districts of Odisha as per request of OMC and made an appraisal of the colluvial, alluvial and eluvial gem deposits and suggested for exploration. From this investigation it was revealed that the gemstones deposits of Kalahandi, Balangir and Sambalpur Districts are comparable with the gem deposits of Minas Gerais of Brazil, Ratnapura of Srilanka and Mogok District of Mianmar.

After discovery of a valuable deposit of ruby in Jillingdhar area of Kalahandi District, the Odisha Mining Corportaion undertook detailed exploration in this deposit after safe guarding the area. Based on the results of geological exploration in Jillingdhar and Hinjilibahal ruby deposits and Budhapara garnet deposit, the author prepared

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mining plan for raising gemstones from these areas and got the plans approved by the Indian Bureau of Mines. This planned action for mining of gemstones was first of its kind in India and was considered as a praise worthy venture. Detailed exploration was taken up in Paik Dhakulaguda area in Koraput District in 1990 for valuable chrysoberyl cat's eye after its discovery. The Odisha Mining Corporation applied for 9 Prospecting Licenses and 3 Mining Leases for gemstones to the State Govt. Based on assurance given by OMC for supply of gemstones, 6 lapidary industries had came up at Bhawanipatna, Balangir, Sambalpur and Bhubaneswar. After coloured gemstones, the State Govt entrusted OMC with the work of development of diamond resources of the State on 24th February, 1994. India was famous for mining of diamond in Mahanadi and Tel valley till 1800. Hirakud near Sambalpur (previously known as the state for 'sambal' or resources) was in the fore front in India for production of diamond. In 1996 the Odisha Mining Corporation in association with the Directorate of Mines and with United Nations Development Programme assistance could implement a project for diamond exploration as per the advice of Dr. J. Garlic. The Odisha Mining Corporation made profit by selling gemstones collected through exploratory mining during the first 10 years of the project (1982-1992) and different varieties of valuable gemstones procured through an experimental auction at Jaipur in 1986 and through public auction at Bhubaneswar during 1987 and 1990. The Odisha Mining Corporation made a profit of Rs.rs.15 lakhs after meeting all the expenses and the profit was paid to the State Govt. towards revenue. In this project the revenue received by the State Govt. was increased by Rs.15 lakhs, but the Odisha Mining Corporation could get the self satisfaction of increasing its knowledge in the science of gemmology.

By implementing this project, besides gemology, many unknown and unseen facts of history could be known. The valuable gemstones are symbol of the glorious heritage and culture of our country. In 4th century BC, Bishnugupta (Chanakya), minister of Emperor Chandragupta Mourya of Magadha, in his treatise on 'Arthashashtra' advised the emperor to dig for gemstones in 'Indrabana' to increase revenue of the state. That Indrabana was not in any where else, but in the middle of Mahanadi and Tel valley having gem tracts as seen from the 'Historical Atlas of South Asia'. In 2nd Century, the Greek Philosopher Tollemy in his thesis has described Mahanadi as Hiranadi of Sambalpur. In 17th century the Jean Baptiste Tavernier, gemstone trader of France, came to India for visiting 3 diamond mines including Hirakud.

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During a courtesy meeting with the then Maharaja of Kalahandi Sri Pratap Keshari Deo in 1988, the author was astonished to see an edition of Encyclopedia Britannica regarding the definition of 'Ruby' or 'Manikya'. It was written that the other name of ruby is red corundum. As it was first exported from an erstwhile state 'Karund' to England, its name is corundum. In astrological terminology, ruby is called 'Manikya' and sapphire is called 'Nila'. It is astonishing that the earlier name of Kalahandi district having rich resources of 'Manikya' and 'Nila' was 'Karund'. Sri Deo showed the author an agreement showing the union of the princely state of Karund with India which he signed in 1948 as the Maharaja. From this it is known that Odisha was rich in gemstone resources from 4th Century BC upto the modern age.

Gemstone in Odisha had from the ancient time religious and cultural linkage. The Gemstone deposits of Odisha confined to the Western districts of the state are interestingly linked with the temples of 11th century, which are epitome of cultural heritage of the state. The presiding deity of Bhawanipatna is named as Manikeshwari (Goddess of Ruby) around which Ruby deposits occur in Kalahandi District. Similarly, the presiding deity of Patnagarh is named as Panneswari (Goddess of Emerald) in the vicinity of which Emerald was won and smuggled out to Europe from Antarla of Bolangir district of Odisha. The presiding deity of Sambalpur is Sambaleswari (Goddess of Resources) from where diamond is being mined from the river bed of the Mahanadi. These depicts the religious and cultural bondage of gemstones in the state from the prehistoric age and it is evident that Odisha played a significant role for exploitation of gemstone in the East from ancient time and well known for its gem potential.

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CHAPTER-I

INTRODUCTION

1.1 Introduction:

Gemstones have attracted mankind from time immemorial. Many battles have been fought, history has been obliterated and cultures have been influenced by man's love and lure for gemstone. The fascination of gemstones have been the source of vision for Explorers and Adventurers, hall mark of majesty and status symbol for Emperors and Kings, an ardent objective of Philosophers, an effective tools for ancient and Medieval Physicians, a potent talisman for warriors, a lucrative personal adornment and aesthetics for common man and of course, a strategic wealth for a kingdom as well.

Indian has a rich heritage of Gemstone. In India the story of Gemstone dates back to the Epic age of Mahabharata inscribed 5000 years ago in which Diamond being the king of all gems has been mentioned. It is said that King Karna (the son of Surya) used to wear a dazzling stone of light in his forehead, which made him invincible and courageous to challenge Arjuna the most valiant Pandava.

No authentic source of study of gemstone in India was available till the discovery of a Sanskrit manuscript namely Arthasastra in 1905, written by Kautilya, the Minister of the King of Magadha, Chandragupta Maurya (320-298 BC), the first Emperor of India in 4th Century BC. Kautilya, who was popularly known as Chanakya in his treatise of Arthasastra has not only advised the Emperor Chandragupta Maurya to dig for diamond in the valley of Indravana, when the country is short of resources, but also suggested a set of rules and practices developed by specialist to regularize taxes, custom duty etc. applied to diamond and other precious stones. Chanakya's valley of Indravana is no where but in the Bastar Craton of Odisha and Chhattisgarh border, recently explored to contain potential diamondiferous lamphroite / kimberlite pipes as primary source of diamond.

Apart from that there are two important texts on Gemstones in India from which valuable information and contemporary activities on Gemstones in Medieval period is known. They are Ratna Parikhya written by Bhudhabhatta in Fifty Century AD and Brihat Samhita written by Varaha Mihira in Sixty Century AD which depict most interesting information regarding the precious stones. In these treatise emphasis

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been given on diamond, being already rare and hardest of all known gems. The texts describes the octahedral form of diamond and optical characters like colour, clarity, transparency, fire and iridescence, which has been recently defined on scientific basis on the Twentieth Century after development of science of Gemmology. The Hindus thought that the octahedron form of diamond was important for its rarity and it was only an octahedral crystal of diamond which displayed highest reflectivity and dispersion of light.

In the Seventh Century, the Chinese Traveller, Heuen Tsang visited India (629-645 AD) and described the wonderful diamond throne, which stood near the tree of knowledge, the 'Kalpa Tree' of Hindu religion, beneath whose spreading branches, Gautam Budha is said to have received the Supreme revelation of Truth. This throne was said to have been constructed in the age of "Kalpa of the Sages" and its origin was contemporaneous with the origin of the Earth. The throne had a circumference of hundred feet having central focus point.

Five centuries later, the Venetian Marco Polo, who was the first cultured European to visit India, in his Book of Marvel (1289) has described regarding the myth, legend and business of gemstones in India and in the far East countries.

Jean Baptiste Tavernier, a French Gem Merchant of great courage and curiosity made several voyages to India (1631-1671 AD) in pursuit of gems and jewellery and has given a rich and valuable account of gemstones in India. He visited three mines in three different times out of several diamond producing mines of the country at Raolconda in South of Hyderabad, Kollur in the Krishna River basin in Andhra Pradesh and Sambalpur in the gem gravel of the Mahanadi in Odisha. His description of mining was no different from the present day practice of mining alluvial deposit, where thousands of people were engaged and working in the scorching sun in search of diamond, at a period when India was the principal diamond producing country in the world. The young French man was equipped with foreign languages and acquired the nack of interaction and determined to see the places of gems and jewellery.

In Seventeenth Century, the Moghul Emperor Aurangzeb owned the most fabulous collection of gems and jewellery of the world. In 1668, Tavernier, a great connoisseur of gemstones had the access to view the Moghul Treasure of Aurangzeb. He perceived the marvelous peacock throne, jeweled with gold and studded with Diamond, Pearl, Ruby (108 carats), Sapphire and Emerald (116 carats). He also viewed the royal gems, where he was shown a piece of topaz of 158 carats, spectacular Diamonds, Rubies and Emeralds. The French Merchant had also a feel of round rose

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cut diamond weighing 280 carats Known as Great Moghul fashioned from a giant crystal of 787 carats, which was mined from Golconda diamond field of Andhra Pradesh few years back, supposed to be largest piece of diamond at that point of time.

1.2 What are Gemstones ?

Gemstones are those materials, which after being cut and polished, are attractive and durable enough to be used as personal adornment. Beauty, durability and rarity are the three distinguished qualities of gem materials, which are to be called as gemstone.

Beauty is the basic characteristics of a gemstone for use in jewellery. This may be due to colour, luster, transparency and consummate fashioning. To some, beauty may be in the penetrating colour, to others it may be in the attractive luster, transparency and fire emanating from skillful fashioning. If the gemstone is a transparent coloured gem, the depth of colour and degree of transparency may be the governing factor of beauty. For instance, beauty of diamond could be judged for its brilliancy, fire and optical purity, where as for precious opal, it may be for its iridescent play of colour.

Durability is the second essential quality of a gemstone, which depends its physical properties; hardness and toughness. Diamond is most durable gem for its hardness, which is essential for lapidary cutting and fashioning. Similarly Jade and Corundum, though not as hard as diamond, are durable for their toughness.

Rarity is also an essential attribute of a gemstone, which enhances the value of gem materials. This is based on economic consideration of supply and demand and fashion rather than on its intrising properties. Amethyst was once a rare and expensive gemstone for a long period until amethyst deposits were discovered in Brazil.

The gems are weighed in unit known as carat. There is a tree known as Carob tree, which grows in the East and in countries bordering the Mediterranean. For thousand years, the gem traders all over the East used the tiny black seeds of the Carob tree to weigh their gemstones from which the term carat has been derived. With the improving accuracy of weighing scale, it became important to weigh gemstone in metric scale and to standardize the metric carat. In event of the fact that the weight of a Carob bean seed was around 190-195 milligram and marginally short of one metric carat, International Committee on Weights and Measures agreed that 200 milligrams should represent a metric carat which has been adopted

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internationally since 1930 and in practice now all over the world. The unit measurement of length of gems is however millimeter by which the diameter of the bids are measured.

Gemstones are basically superior varieties of minerals formed in different geological environment in the earth crust. Out of 3000 mineral species formed in the earth crust, around 30 reasonably posses the charismatic characteristics of gemstones depending upon their physical, visual and optical properties like colour, transparency, cleavage, parting and fracture, hardness, specific gravity, refractive index, chatoyancy, asterism, pleochroism, colour change, labradorescence, adularescence and aventurescence. The carbon forms the diamond in an articulate geological environment. The silicates constitute the largest varieties of gemstones, the oxides forming the second largest, the carbonates, sulphides, phosphates and sulphates forming small groups of the spectrum of gemstones. Some organic materials like Pearl, Amber, Coral and Ivory etc. are although used as gemstone but not termed as gemstone as they are not mineral species.

Table-1.1: List of gem groups

Group	Gem Minerals
SILICATES	Emerald, Aquamarine, Heliodor, Morganite, Topaz, garnets like Pyrope, Almandine, Rhodolite, Spessartite, Grossularite & Andradite, Tourmaline, Peridot, Zircon, Lapis Lazuli, Moonstone, Amazon stone, Kunzite, Hiddenite Iolite, Sillimanite cat's eye, Sphene, Jade, Zoisite, Spinel.
OXIDES	Ruby, Sapphire, Chrysoberyl, Alexandrite, Amethyst, Citrine, Tiger's Eye, Aventurine, Chalcedony, Opal
CARBONATE	Calcite, Smithsonite, Rhodochrosite, Malachite, Azurite.
SULPHIDE	Pyrite
PHOSPHATE	Tourquoise
SULPHATES CARBONORGANIC	Barite, Celestite, Anglesite, Diamond Pearl, Coral, Amber, Ivory

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Gemstones are currently appropriately called gem materials to encompass full range of inorganic and new gem substance.

1.3 Classification of Gemstones

Gemstones are classified into two categories; Precious and Semi Precious stones. The precious stones consist of Diamond, Ruby, Sapphire & Emerald and rest of the stones like Alexandrite, Aquamarine, Garnets, Chrysoberyl Cat's Eye, Iolite, Zircon, Topaz, Amethyst, Citrine, Moonstone, Opal, Sillimanite Cat's Eye etc as semi precious stones. But this terminology is not used by the industry currently and the entire species gemstones are categorized as coloured gemstones.

Based on some composite characteristics comprising hardness, colour, transparency, luster, polishability, rarity, price and market demand, Bauer (1904) classified gemstones into five ranks which are as follows:

Table-1.2: Ranks of gemstones

Rank	Name of the Gemstones	Characteristics
First	Diamond, Ruby, Sapphire, Chrysoberyl, Spinel	The hardness in Moh's scale varies between 8 and 10. The gemstones are either pure carbon, alumina or predominantly with alumina
Second	Garnet, Zircon, Topaz, Tourmaline, Beryl, Emerald	The hardness varies from 7 to 8, the specific gravity being 3 +. The minerals are mostly silicates. Perfect specimen may be valued higher than the 1st rank gem.
Third	Iolite, Turquoise	The hardness varies from 6 to 7, the specific gravity being higher than 2.5 barring turquoise.
Fourth	Chalcedony, Opal, Moonstone, Amazon stone, Lapis Lazuli	The hardness varies from 4 to 7, the specific gravity between 2 to 3. Colour, luster and transparency are the main features, but wide spread.
Fifth	Serpentine, Malachite, Rhodochrosite, Agate	This is characterized by low hardness and specific gravity and luster, transparency too and attracts obviously low price.

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1.4 Use of gemstones

The utility of Gemstones are manifold. The ancient treatise on gemstones by different authors have given an account of various uses of gemstones.

The great ancient Greek Philosopher Pluto (360 BC) originated a theory that the stars and the planets converted decayed and decaying matter into perfect gemstone. THEOPHRASTUS, the Greek Philosopher and Naturalist propounded a fanciful theory that there exist a male and female gemstone in his encyclopedia HISTORIA NATORALIS. Roman Philosopher Pliny (77 AD) postulated a theory that gem crystals are formed by action of intense cold, where winter snow have gathered in caves and caverns. Therefore the ancient thought that the gems are of supernatural origin and ascribed them to have possessed all pervading mystic, magic and talismanic powers.

Dioscorides, the first Greek Physician wrote Materia Medica, which remained the text book of pharmacy for 1600 years in Greece, the fifth volume of which is dedicated to use of 200 stones as medicine. Gladius Galen (131-200 AD), the most famous Green Physician, detailed the use of gemstone as medicine.

In Indian text of 'Ratnaparikhya' of Budhabhatta in 5th Century AD, it is said that "he who wears a diamond will see dangers recede from him, whether he is threatened by serpents, fire, poison, sickness, thieves, flood or evil spirit" which bears to the testimony of gemstone being used as talisman in ancient times.

In Middle Ages, Marbode, the Bishop of Rennes (1067-1081) wrote a treaty on Lapidary in Latin hexameter. Albert Magnus, the Bishop of Ratisborn authored Secrets de Virtus des Herbes, Pierres et Bestes (1193-1280), which describes the medical use of gemstone.

Bartholomaeus wrote a handbook on gemstone for use by teachers and monks entitled De Proprietatibus Rerum, Sir John Mandeville, the Fourteenth Century French author wrote on travels and voyages having treatise on gemstones. In Sixteenth Century and Seventeenth Century writers like Camillus Leonardus authored Speculum Lapidum (1502 AD) which was translated to English Mirror of Stone (1750). Later Thomas Nicholas wrote on the History of Precious Stone (1652) and Faithful Lapidary (1659) describing several use of gemstones including lithohealing. Dr. Johannes Schroeder authored The Complete Chemical Dispensary (1669) depicting the use of gems in medicine in Latin which was later translated by Dr. William Rowland to English. In the beginning of the Nineteenth Century AD Prof. Francis Barrett (1801) wrote The Celestial Intelligencer about the supernatural properties of metals,

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AQUAMARINE

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gemstones and herbs. Raja Sourindra Mohan Tagore of India wrote a treatise on gemstones (1879) describing the magical and healing properties of gemstones in Indian folklore.

The above treatise of ancient Greece, Roman and Indian civilization gave a fair details of the legend of gemstones being used by man down the centuries mostly as talisman and medicine based on magic, myth and superstition rather than on the science. The analysis of above treatise on gemstones depicts that upto the later part of sixteenth century, gemstones were used mostly as talisman and medicine with little regard to beauty and adorn.

1.4.1 Gemstones as talisman

It is said that Roman Catholic Cardinals used to wear blue sapphire in their rings because of medieval belief that these stones imparted purity, just as purple amethyst bought sobriety and emerald bought tranquility. The red stones Ruby and Garnets were severally used as talisman by warriors and soldiers especially in East and Middle East countries. In India red diamonds were used by the Khatriyas, the Warriors prescribed to the community, the colourless diamonds for Brahmins, the Vaishyas (Baniks), yellow diamond for Sudra (Labour / artisans) and dark grey diamond as Talisman. The gems like blue sapphire were used as potent talisman for good health, zircon as talisman for merchants for wealth and happiness. The Egyptian used Carnelian as talisman for black magic and bad temper. Ursula Markham in Crystal and stones has mentioned that the lithohealers strongly suggest using Cat's Eye as an effective talisman against hypochondria and all sorts of psychosomatic diseases.

1.4.2 Gemstones as medicine

Gemstones have been widely used as medicine as well over countries. Diamond, the most precious of all gems have been used for plague, psoriasis and bladder ailment, Ruby as an Universal Panacea for spleen and lever disorder, versatile emerald for jaundice, diabetics and epilepsy, blue sapphire for cure of fever, plague and eye-diseases, Lapis Lazuli for cure of epilepsy and purging melancholy, topaz for cure of skin diseases and gout and amethyst against consumption, coral for colic and convulsion.

The list of therapeutical use of different gemstones revealed from above mentioned classical treatise of ancient and medieval writers of Greek, Roman and Indian civilization, on lithohealing by gemstones are cataloged in Table 1.3. The following list has been drawn up from the writings of Theophrastus, Pliny, Dioscorides,

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Galen, Camillus Leonardus, Cantimpre, Beauvais, Dr. Johann Schroder, Dr. William Rowland and many others.

Table 1.3 : List of healing gems

ILLNESS	GEMSTONE
Ague	Sapphire
Allepo Boils	Agate
Apoplexy	Lapis Lazuli
Arthritis	Amber
Asthma	Amber, Jade
Bad Temper	Carnelian, Zircon
Biliousness	Jade (Purple / Yellow)
Bladder problems	Bloodstone, Flint, Haematite, Diamond
Blood purification	Jade, Lapis Lazuli, Coral
Boils	Agate, Sapphire
Bone Problems	Jade
Cataract	Sapphire
Catarrh	Amber
Chest and lungs	Agate, Amber, Carnelian, Jade
Cholera	Malachite
Colic	Coral, Rock Crystal
Constipation	Emerald
Contagious diseases (Protection against)	Coral, Opal
Contentiousness	Agate
Convulsions	Coral, Malachite
Cramp	Flint
Croup	Amber
Curdled Milk	Flint
Depression	Lapis Lazuli

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Dermatitis	Diamond
Dread	Tourmaline
Dropsy	Rock, Crystal, Serpentine, Zircon
Drowning (protection against)	Garnet
Duodenal Ulcer	Sapphire
Dysentry	Emerald, Rock Crystal
Ear infections	Amber
Envy	Agate
Epidemics	Agate, Coral, Opal, Zircon
Epilepsy	Eagle Stone, Moonstone, Cotal
Evil Eye	Agate, Black Onyx, Coral, Turquoise
Evil Sorcery	Amethyst, Coral, Flint, Malachite
Evil Spirits	Diamond, Topaz
Evil Thoughts	Garnet, Hydrolite
Excitability	Bloodstone, Jade
Exorcism (used in)	Emerald
Eye Complaints	Coral, Emerald, Haematite, Lapis Lazuli, Opal, Ruby, Sapphire, Topaz, Tabasheer
Eye Strain	Emerald, Topaz, Turquoise
Faintness	Jet
Falling Sickness	Agate, Eagle Stone, Jet, Turquoise, Jade
Fear	Agate, Ruby
Fever	Amber, Red Garnet, Moonstone, Sapphire, Tabasheer, Zircon
Foot complaints	Hydrolite, Jade
Gall Stones	Bloodstone, Rock Crystal
Gastritis	Emerald
Gout	Amethyst, Hydrolite, Rock Crystal, Topaz

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Haemorrhage	Agate, Bloodstone, Carnelian, Coral, Garnet, jade, Eagle Stone, Ruby, Topaz
Haemorrhoids	Bloodstone, Topaz
Hay Fever	Amber
Headache	Amethyst, Haematite, Lapis Lazuli
Incontinence	Garnet
Incubii (protection against)	Diamond
Indigestion	Agate
Insanity	Agate
Insomnia	Agate, Amethyst, Malachite, Zircon
Intoxication	Amethyst
Jaundice	Yellow Garnet, Yellow Topaz, Yellow Zircon
Kidney Problems	Agate, Bloodstone, Flint, Haematite, Jade, Malachite, Rock Crystal
King's Evil	Jet
Labour pains	Eagle Stone (aetite), Flint Celts, Jade, Lapiz Lazuli
Leg complaints	Jade
Leprosy	Emerald
Liver complaints	Amethyst, Coral, Jade, Ruby, Tabasheer
Loose Teeth	Agate, Carnelian
Loss of appetite	Emerald
Loss of Courage	Diamond, Sapphire
Loss of Energy	Diamond
Loss of Inspiration	Hydrolite
Loss of sense of smell	Bloodstone
Loss of strength	Diamond
Loss of voice	Carnelian, Jade

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Melancholia	Garnet, Lapis Lazuli, Opal, Tabasheer, Topaz, Zircon
Mental health	Ruby, Sapphire
Neuralgia	Amethyst, Lapis Lazuli
Nightmares	Diamond
Nursing Milk	Flint, Malachite, Rock Crystal
Pestilence	Agate, Ruby
Plagues	Amethyst, Diamond, Emerald, Garnet, Ruby, Sapphire, Zircon
Poisons	Amethyst, Eagle-Stone, Emerald, Garnet, Sapphire, Tabasheer, Topaz, Turquoise, Unicorn Horn, Zircon
Possession by demons	Emerald, Turquoise
Psoriasis	Diamond
Rabies	Topaz
Rheumatism	Flint, Malachite
Sea Sickness	Agate
Sexual disorders	Ruby
Skin disorders	Lapis Lazuli, Sapphire
Snake Venom	Emerald, haematite, Snake-Stone, Tabasheer
Sterility	Coral, Moonstone
Stomach Disorders	Amethyst, Coral, Jade, Malachite, Parian Marble, Tabasheer
Teething	Coral, Malachite
Tender Gums	Agate
Terror	Tourmaline
Timidity	Lapis Lazuli, Tourmaline
Tired Eyes	Agate, Sapphire, Topaz

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Tonsillitis	Amber
Toothache	Amethyst, Jet
Tumours	Amethyst, Carnelian
Ulcers	Agate, Sapphire, Topaz
Vertigo	Agate, Sapphire, Topaz
Warts	Flint
Weak heart	Coral, Garnet, Jade, Malachite, Zircon
Wounds	Haematite, Garnet, Rock Crystal

It is only in the Seventieth Century the scientists have come to know that the gems are noble creation of nature and ever since the science of gemology evolved in nineteenth century, more deposits of gems were discovered throughout the world. There was development in medical science and skillful fashioning of gemstones. The duplication of natural gemstones by chemical processes increased. There was reciprocative change in the pattern of utilization of gemstone by mankind all over the world. There was increasing trend in use of gems for personal adornment in Royal Throne, Royal Crown, Sceptre, Sword, bracelet and jewelleries followed by use of gems for astral effect and human aesthetics. The concept of 'Navaratna' in Hindu philosophy, the concept / use of Gemstone as Birthstone and Zodiac stone by English speaking countries, crystal therapy by Chinese and more recently the use of gemstone for generating laser beams to measure small objects in moon in this period of time, mostly in twentieth and 21st century shows the versatile uses of gemstones. The use of Gemstones at present is continued to

- Gems for personal adornment / Aesthetics
- Gems for Astral Effect
    - ✓ Navaratna
    - ✓ Zodiac Stone
    - ✓ Birthstone
- Gems for Crystal Therapy concept of Chakra
- Gems for Scientific use

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1.4.3 Gems for personal adornment

It is nothing but true that man tried to adorn himself with gems, much before he learned to clad himself with clothes. In an archeological excavation in Lake dweller's Grave in Butan, Czechoslovakia recovered some garnet pebbles in which holes have been made, strongly suggest that the Bronze Age people 5000 years above were adorning them with gemstone bids. In Egyptian in VI Dynasty in 3000 BC used necklace of broad bead collars of Gold, Lapiz Lazuli, Carnelian and torquiose, which depicts the ornamental use of gems and jewellery in those days. It is only in Sixteenth Century, the use of gemstones in jewellery could come to lime light in the costumes of the Kings and Emperors of contemporary history. Sir Thomas Rowe, an English Ambassador has described that the costume of Moghul Emperor Jehangir (1569-1627), the turban being decorated with Diamond, Pearls, Ruby and Emerald and his bracelets were studded with diamonds bear evidence to the fact that the gemstones were used in the costumes of the Royal families. There has been contemporaneous evidence of development of jewellery where the precious stones were studded with gold jewellery for use as necklace for beauty and adornment. The art and crafts of jewellery registered development mostly in the Eighteenth Century, which was considered as the age of jewellery. It is only after the Second World War there was development of modern jewellery of fine craftsmanship with colourful combination of gems enameled with gold, platinum and silver in form of necklace, garland, chair, rings etc. after the common man took interest in fashioning them with adornment of gems and jewellery. Since then there has been increasing demand of coloured gems and diamond in the jewellery industry in Nineteenth and Twentieth Centuries. The production of Gemstone, development of Fashioning Industries and jewellery Industries and marketing of gemstones in the world are significantly controlled by the ardent objective of use of gemstone by mankind for beauty and adornment.

1.4.4 Gems for planetary and astral effect

Gemstones are being used by mankind for use of astral and talismanic effect through out the world mostly in East, Middle East and European Countries from the fag end of nineteenth century onward. The concept of Navaratna; nine gems being dedicated to mine planets in Hindu Philosophy has a great impact in use of gemstone, by people for using a estimated gemstone related to the planet which governs the life cycle of the man.

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Table-1.4: List of gems with planets

Sl.	GEMS	PLANETS
1.	Vajra (Diamond)	Venus
2.	Manikya (Ruby)	Sun
3.	Vaidurya (Cat's Eye)	Ketu
4.	Gomedha (Zircon)	Rahu
5.	Mukta (Pearl)	Moon
6.	Pravala (Coral)	Mars
7.	Marakata (Emerald)	Mercury
8.	Phshyaraga (Topaz)	Jupiter
9.	Nilam (Sapphire)	Saturn

The science of gemology reveals that gemstones belong to Mineral Kingdom and interestingly the mineral constituents of a gemstone related to a particular planet is same as that of the planet and behaves as a miniature planet. As per the concept of NAVARATNA, these are nine gemstones representing nine planets, dark red coloured ruby for Sun, white pearl for Moon, red Coral for Mars, green emerald for Mercury, yellow sapphire for Jupiter, colourless diamond for Venus, blue sapphire for Saturn, yellowish brown Gomedh for Rahu and coloured / colourless Cat's Eye for Ketu. The diseases and suffering in the human body is caused due to contraction and expansion of the endocrine glands depending upon the types of colour-vibrations due to the effect of the planet in human body.

Dr. Oscar Burnler United States of America has scientifically proved the concept of Navaratna by measuring the radiations of the gems and planets, which happen to be the source of energy. He has successfully measured the relations of the planets and also gemstones related to the planet depicted in Table 1.5.

Table- 1.5 : Wavelength of Planets and Gemstones

Sl.	Planet	Wavelength in 10^{-8} cm^2	Gemstone	Nature of Gems	Wavelength in 10^{-8} cm^2
1.	Sun	65,000	Ruby	Hot	70,000

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2.	Moon	65,000	Pearl	Cold	70,000
3.	Mars	85,000	Coral	Hot	65,000
4.	Mercury	85,000	Emerald	Cold	70,000
5.	Jupiter	1,30,000	Topaz	Cold	50,000
6.	Venus	1,30,000	Diamond	Hot	80,000
7.	Saturn	65,000	Sapphire	Too Cold	70,000
8.	Rahu	35,000	Gomedh	Cold	70,000
9.	Ketu	35,000	Cat's Eye	Too Hot	70,000

This explains the negative wavelength of a planet (Graha in Hindu Astrology) affecting the human body, when positioned in that time period. When the related gems are worn as per the concept of Navaratna, it acts as a inner active planet and the positive wavelength counter balances the negative effect of gemstone. It is said that the negative wavelengths of planets affecting the human body is counterpoised by the wavelengths of the gemstones one wear to decompose the desired effect on the endocrine glands of human body, which not only cure diseases, but also emulate well being of the man, who wears the gemstone. Therefore, gemstones are quite popular with Indians, those who wear these for attaining good luck.

This concept of Navaratna appears to have confined to Middle and Far East countries for many centuries especially Arabian Countries, China, Burma. The comparative name of nine gems in India, Burma, China and Arab countries are given in Table-1.6. The concept of Navaratna has recently been proved to have been based on Science rather than on talismatic belief as discussed below.

Table-1.6 : List of Navaratna

Sl.	English	Sanskrit	Burmese	Chinese	Arabic
1.	Diamond	Vajra	Chein	Chun-syak	Mâs
2.	Ruby	Manikya	Budmiya	Se-fla-yu-syak	Yâkût bihar
3.	Cat's Eye	Vaidurya	Châno	Mâu-ji gan	Ain al-hirr
4.	Zircon	Gomedha	Gamok	Pï-si	Hajar Yamânî
5.	Pearl	Muktâ	Pa-le	Chun-ti	Lûlû

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6.	Coral	Pravâla	Tadâ	San-ho-chi	Murjân
7.	Emerald	Marakata	Mujâ	Luk-syak	Sumurrud
8.	Topaz	Pushyaraga	Outfiâ	Si-lang-syak	Yâkûlal-azark
9.	Sapphire	Nila	Nilâ	Chang-syak	Yâkûtal-actar

Zodiac Stones

Gems have been believed to bring good fortune to those who are born at a certain time of the year. Zodiac stones or Astral stones are those designated stones, which are believed to have mystically connected to zodiac signs. These signs constitute / represent a twelve fold division of the year. People those who have taken birth in that period of time, wear the designated stone for their good fortune and well being. The use of gemstone for their planetary influence practiced in the East and came to Europe only in 15th century. The list of zodiac stones are given in Table 1.7. Gems are associated with various anniversaries and are believed to bring good fortune to those born at a certain time of year.

Table- 1.7 : Gemstones of the Zodiac

Aquarius	January 20 – February 18	Garnet / Turquoise
Pisces	February 19 – March 20	Amethyst
Aries	March 21 – April 20	Bloodstones / Carnelian
Taurus	April 21 – May 20	Rose Quartz
Gemini	May 21 – June 20	Citrine / Tiger's Eye
Cancer	June 21 – July 20	Emerald / Chrysoprase
Leo	July 21 – August 21	Rock Crystal / Onyx
Virgo	August 22 – September 22	Carnelian
Libra	September 23 – October 22	Peridot / Jacinth
Scorpio	October 23 – November 22	Aquamarine
Sagittarius	November 23 – December 20	Topaz
Capricorn	December 21 – January 19	Ruby

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Birth Stones

The origin and belief that a particular gemstone is dedicated to a designated month as a stone of the month as a natal stone carrying peculiar virtue could be traced back to the writings of Josephus in the 1st Century and of St. Jerome in early 5th century. Both of these authors have discussed the connection between the designated twelve gemstones and twelve months of the year and their effect of well being on human being. In spite of early testimony, the practice of use of these stones as Birthstone of the month was uncommon and not in practice until 18th century, when it was introduced in Poland. The original list of designated gems for designated month since then changed from time to time and place to place with possible explanations given by different theosophians. Different countries used different gems as birthstone of the month from say 15th to 20th centuries by Jews, Romans, Poles, Arabians, Italians and Russians and some English speaking countries. It is only in 1912, National Association of Jewellers at a meeting in Kansas City resolved a satisfactory list of birthstone, which was adopted and is being followed in English speaking countries. The list of birthstones finalized in the City of Kansas and used in the English speaking countries are given in Table 1.8.

Table 1.8 : Gemstones for a Birth Month

Month	Gemstone
January	Garnet
February	Amethyst
March	Aquamarine / Bloodstone
April	Diamond
May	Emerald
June	Moonstone / Pearl
July	Ruby
August	Peridot
September	Sapphire
October	Opal / Tourmaline
November	Citrine / Yellow Topaz
December	Turquoise / Lapis Lazuli

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1.4.5 Gems for Crystal Therapy

Crystals have been used for healing in many civilizations and culture throughout history as discussed in the earlier chapters. The concept of crystal therapy is based on the fact that the healing powers of Gemstone lies on their vibrations they emit. Similarly, vibrations are also created in the human body throughout by creation of electromagnetic field in different energy points called Chakra. The crystal vibrations react with electromagnetic field of the human body that enhances the personal energy of the human body.

The Chakra associations and the Gems prescribed for remedial and curative measures are given in Table 1.9.

Table- 1.9 : Chakra Association

Colour	Chakra	Physical Area	Aspect	Gemstone Therapy
Red	I	Perineum / base of the spine	Survival, Security, Safety	Red Garnet, Smoky Quartz
Orange	II	Adrenals / Abdomen	Strength / Sexuality	Carnelian, Tiger's Eye
Yellow	III	Solar Plexus / Stomach	Personal Power, Ego, Impulses	Citrine, Topaz
Green	IV	Cardiac Plexus / Heart	Compassion, Love	Rose Quartz, Kunzite, Jade
Blue	V	Thyroid Gland / Throat	Creativity, Speech, Writing	Aquamarine, Azurite
Indigo	VI	Pituitary Gland / Forehead	Higher Intuition Psychic abilities	Lapiz Lazuli, Sapphire
Purple / Violet	VII	Pineal gland / top of head	Spirituality, Enlightment	Amethyst, White or Colourless Quartz

Invisible Energies :

As we have seen, people since ancient times have sensed powerful energies emanating from gemstone crystals. Some basis for this has been partially confirmed by the Russian scientist Peter Kirlian, who found that, when photographed in a specific manner, certain organic and inorganic specimens seemed to be surrounded by an energy field that appeared as a radiating pattern.

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Energy on Film :

On film, Peter Kirlian captured what seemed to be electromagnetic fields, around plants, animals, crystals, mineral conglomerates and people. These photographs show patterns that are similar in appearance to those formed by iron filings, when they are used to reveal the presence of a magnetic field. They differ, however, in the fact that they form radiating patterns with no joining at the poles.

For example, a Kirlian photograph of rock crystal, taken perpendicular to the long axis, show these energy fields quite markedly. Through Kirlian photography, previously unseen energy fields emanating from crystals are being charted and the data collected for future use.

The Chakras :

In modern times, "New Age' practitioners have taken to using the energy that they believe lies locked away inside a crystal as a healing force.

These healers work on the basis that the colour of the selected crystal should correspond closely with the main energy points of the body – which they know as "Chakras" although colour selection will often be the personal choice of the practitioner.

The name Chakra is taken from Sanskrit and translates to "wheel of light", as this is what a chakra appears to represent when photographed with Kirlian photography. According to New Age thought, chakras are located in specific sensitive areas and influence the endocrine (hormone-releasing) glands. There are many minor chakras, but only seven main ones, each of which is associated with one of the seven colours of the natural light spectrum.

Healing Centres :

When it comes to healing, energy generated by a prism of rock crystal, or crystal of an appropriate colour, is directed by the healer at a specific chakra, depending on the needs of the individual.

The seven charted chakras are said to be at :

1. The Crown of the head
2. The brow
3. The throat

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4. The heart
5. The solar plexus
6. The abdomen
7. The base of the spine around the coccyx

The chakra at the "crown" of the head influences the cone shaped pineal gland in the brain, it is the entry point for those energies that flow through the body and eventually meet up with the root chakra. Its associated colour is violet.

Input energy at the brow chakra influences the pituitary glands, this is the energy centre of spirituality and is the location of the subconscious mind, its associated colour is indigo.

The thyroid gland is influenced by energy directed to the throat chakra – the seat of communication, its associated colour is blue.

The heart chakra, positioned directly over that organ, is the energy centre that motivates emotions such as love and compassion. This chakra also influences the thymus, which plays a major role in the immune system. Its associated colour is green.

Energies absorbed at the chakra of the solar plexus stimulate the pancreas and liver, this is the centre that controls how energies are exchanged with other people. The associated colour is yellow.

The chakra of the spleen or lower abdomen exerts its influence on the spleen, the liver and adrenals. It is the area where "gut instincts" are said to be situated. Its associated colour is orange.

The "root" chakra, at the base of the spine, controls physical vitality. The endocrine glands influenced by this chakra are the gonads, and the associated colour is red.

Good Vibrations :

"......So much is true, that gems have fine spirits, as appears by their splendor, and therefore may operate, by consent, on the spirit of men, to strengthen and exhilarate them. As for their particular properties, no credit can be given to them. But it is manifest that light, above all things, rejoice the spirits of men, and probably, varied light has the same effect, with greater novelty, which may be one cause whey precious stones exhilarate" Francis Bacon, Writer (1561-1626).

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Much has been written on the supernatural powers and the healing "vibrations" and energies of crystals and gemstones. Anselmus Boetius de Boot, author of a most important lapidary entitled Gemmarum et Lapidum Historia (published in 1636), believed that, as products of nature, gemstones in themselves did not have the power to create supernatural effect. He goes on to say that : "any such that may appear to be accomplished through them are due not to them but to God or to a good or evil spirit subject to him who uses them only as an instrument."

Magic, Religion and Science :

Over 2000 years ago, Plato devised an interesting theory. This theory suggested that decayed matter became gradually converted into perfect gemstones as a result of influences exerted by the stars and planets. The theory appears to have been eagerly adopted by ancient astrologers and magical diviners who devised systems to foretell he future for their clients.

Gnostics and other religious groups used gemstones in their ceremonies, countless physicians used them for their supposed healing forces, and modern day scientists employ gemstones and other crystals – natural and man-made to generate laser beams with which they are able to measure small objects on the moon with great accuracy.

Vibrations :

There are some who will argue that, as all matter is constructed of atoms, any kind of matter actually vibrates.

1.4.6. Gems for scientific use

Gemstones are being used by scientists now-a days to generate laser beams with which they are able to measure small objects on the moon and other planets. Perhaps it is not known to many that gemstones and crystals are integral part of our life style which are used in telephones, television and radios. Rubies are used for lasers and silicon chips run our computers.

1.4.7 National Gems

Depending upon the combination of the planets in a Zodiac sign or due to the light emanating from the stars / planets, there will be influence and impact of a gemstone on the fate of a country. Depending upon this criteria, George Frederick Kunz has evolved national gems of 55 countries of the world which is significant and interesting (Table-1.10).

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Table 1.10: National Gems

Name of the country	National Gem	Name of the country	National Gem
Alaska	Garnet	Japan	Rock Crystal
Algiers	Coral	Korea	Abalone Pearl
Arabia	Pearl	Madagascar	Morganite
Czechoslovakia	Opal	Mexico	Obsidian
Belgium	Crystal	Morocco	Coral
Bohemia	Garnet	New England	Tourmaline
Bokhara	Lapis Lazuli	New South Wales	Opal
Bolivia	Lapis Lazuli	New Zealand	Jade
Brazil	Tourmaline	Norway-Sweden	Carnelian
Burma	Ruby	Panama	Agate
Canada	Sodalite	Persia / Iran	Turquoise
Cylone	Cat's eye	Peru	Emerald
Chili	Lapis Lazuli	Philippines	Pearl
China	Jade	Portugal	Chrysoberyl
Congo	Diaptage	Rumania	Amber
Denmark	Agate	Russia	Rhodolite
Egypt	Peridot	Sandwitch Island	Olivine
England	Diamond	Scotland	Cairugoru (smoky quartz)
France	Pearl		
Germany	Amber	Servia	Coral
Africa	Diamond	Siam (Thailand)	Ruby
Greece	Sapphire	Sicily	Amber
Holland	Diamond	South Africa	Diamond
Hungary	Opal	Spain	Emerald
India	Pearl	Switzerland	Rock crystal
Ireland	Precious serpentine	Turkistan	Jade
		Turkey	Turquoise
Italy	Coral	USA	Sapphire
		Uruguay	Amethyst

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1.5 Gemstones in India

The Great Classics of Pliny (77BC), Chanakya (4th Century BC), Marcopolo (13th Century AD) and Howard (1677 AD) described by Bauer (1904) depicts rich heritage of gemstones of India with regard to their geology and occurrence in different states, which were in limelight for its rich occurrence of coloured gemstones. The state of Orissa is in forefront for rich occurrence of Diamond, Ruby, Sapphire, Emerald, Alexandrite, Aquamarine, Garnet, Topaz, Zircon, Tourmaline, Iolite, Chrysoberyl Cat's Eye, Sillimanite Cat's Eye etc. since centuries contined to vast spread out of Eastern Ghat granulite belt.

Kautilya (330 BC), the Pioneer Mineral Economist of the World, in his treatise Arthashastra has advised the Emperor Chandragupta Maurya to dig for diamond, when he is short of resources, in the Indravana, an area being demarcated as rich diamondiferous diatremes in Chhattisgarh and Odisha. The diamond mining in Andhra Pradesh was significant in 16th and 17th century from where famous Golconda diamond was mined and diamond mining in Odisha was prominent in 18th century. The Greek Philosopher Ptolemy has described regarding the diamond river of Sambalpur with an obvious reference to the river Mahanadi having Hirakud (Diamond point) being the locale of diamond mining. Valentine Ball (1799) of Geological Survey of India has discussed regarding the mining of diamond around Sambalpur in the river bed of the Mahanadi. The Majhgaon Pipe of Panna was discovered by Captain Franklin in (1827), although the diamond mining in the area dates back to Moghul Empire.

In the Encyclopedia Britanica, 'Ruby' has been described as Red Corundum, which was first exported to London from an Eastern state of India namely "KAROND", the erstwhile name of the princely state of Kalahandi in Odisha enriched with ruby deposits like Jillingdhar and Hinjilibahal.

The state of Tamilnadu was earlier called as 'Kongunadu' (Sapphire Country). The world famous Sapphire like Star India and Midnight Star, both from India were mined from this state.

1.6 Cultural Linkage of Gemstones

Gemstone in India had from the ancient time religious and cultural linkage in the country. The Gemstone deposits of Odisha confined to the Western districts of the state are interestingly linked with the temples of 11th century, which are epitome of cultural heritage of the state. The presiding deity of Bhawanipatna is named as

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Manikeshwari (Goddess of Ruby) around which Ruby deposits occur in Kalahandi District. Similarly, the presiding deity of Patnagarh is named as Panneswari (Goddess of Emerald) in the vicinity of which Emerald was won and smuggled out to Europe from Antarla of Bolangir district of Odisha. The presiding deity of Sambalpur is Sambaleswari (Goddess of Resources) from where diamond is being mined from the river bed of the Mahanadi. These depicts the religious and cultural bondage of gemstones in the country from the prehistoric age and it is evident that India played a significant role for exploitation of gemstones in the East from ancient time and well known in the world for its gem potential.

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CHAPTER II

SCIENCE OF GEMSTONE

2.1 Introduction

Gemmology is the science of gemstones evolved from the science of Geology, Chemistry, Optical Physics, Botany, Zoology and Marine Biology pertaining to gemstones. Although Thomas Nichols authored a book on gemstones as early as 1652, it was only in the later part of twentieth century, the science of Gemmology emerged as an offshoot of Geoscience based on the scientific studies made by several mineralogists, gemologists and Gemmological Institutes of the leading gem producing countries of the world over years.

In early twentieth century, discovery of pink Kunzite (1902) and mining of famous Cullinan diamond from South Africa (1905), discovery of brown variety of Peridot in Srilanka named Sinhalite (1954), discovery of radioactive gem mineral in gem gravel of Srilanka as Ekanite (1965) and discovery of transparent Zoisite in Tanzania named as Tanzanite (1960) were no doubt milestones in the development of science of Gemmology. Ever since, synthetic Spinel (1930), synthetic Ruby (1934) and synthetic Emerald (1940) crystals were produced, the pace of gemstone synthetics got accentuated and as a result in the mid-twentieth century, varieties of Ruby, Sapphire, Emeralds and Diamond produced commercially flooded the gemstone market. In 1959, Dee Beers Diamond Research Laboratory. Johannesburg successfully synthesized diamonds. In 1975, alexandrite variety of chrysoberyl was synthesized followed by synthetic opal. This poised serious concern for the gemologists for their identification and valuation.

In the field of gem testing, Dr. Herbert Smith invented a refractometer for determining refractive indices of gemstones in England (1905). Gemmologists like Basil Anderson and C J Payne (1930) carried out extensive research on gem testing and identification. In the same year, Robert Webster achieved success on the use of Ultraviolet rays for identification of gemstones and innovative Chelsea Emerald Filter (1934) to distinguish Emerald from their stimulants. LC Trumber (1959) also developed Reflectance meter for assessment of reflectivity of gemstone. Is was perhaps a necessity to develop gem-testing instruments and identification techniques, which were highly essential for identifying and distinguishing modern synthetic gems

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appearing in the market from the natural counterpart. The culmination of these sustained endeavors formed the basis for evolution of the science of gemology.

German Scientist Edward G. Gubelin (1953) pursued result-oriented research and established the pattern of inclusions and growth characteristics in gem crystals and published the book 'Internal World of Gemstones" (1974), which could be relied upon to diagnose and segregate sophisticated synthetic gems; the physical, chemical and optical properties of their natural counterparts being identical. The DTC Research Centre of DE Beers in U.K. developed Diamond Sure and Diamond View instruments (1996) for identification of natural and synthetic diamonds. These scientific achievements were nevertheless landmark development for crystallizing modern science of Gemmology.

The Gemmological Association of Great Britain was founded in London (1908) in early twentieth century. The Gemological Institute of America was founded in Los Angeles (1931) followed by German Gemmological Association in Idar- Oberstein (1932), Gemological Association of Australia in Sydney (1945), Canadian Gemological Association in Toronto (1958), and Asian Institute of Gemological Science in Bankok (1978) and Gemmological Instititute of India in Mumbai stood as citadels of gemological education, research and break through discoveries and had significant contributions fostering Gemmology as a faculty of science.

Gemmology or science of gemstones not only includes the study of its origin and occurrences, but also entails upon its characteristic properties, identification techniques and techniques of fashioning to enhance its beauty and value. The science also deals with the study of synthetic gemstones and the gemstone stimulants, the study of organic gems and their stimulants that has no doubt enriched the science of gemology.

2.2 Characteristic properties of gemstones

Gemstones are basically gem minerals and the modern science of gemstone is nothing but a synthesis of geology, chemistry, and physics of gem minerals. From the science of Geology, we understand the physical, chemical environment under which the gemstones are formed in the Earth's crust and of course the geological parameters one has to adopt for prospecting and mining of gemstones occurring in different geological formations. On the other hand, the science of chemistry and physics depict the physical, chemical and optical properties of a gemstone depending upon its complex chemical composition and crystal structure. The physical, chemical and

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optical properties that characterize gemstones and form essential elements of science of Gemology are discussed below. They are

- Crystal Structure
- Cleavage, Parting and Fracture
- Hardness
- Specific Gravity
- Crystal Chemistry
- Colour
- Lustre
- Transparency
- Refractive Index
- Chatoyancy
- Asterism
- Pleochroism
- Colour Change
- Iridescence
- Labradorescence
- Adularescence
- Aventurescence
- Tenebrescence
- Inclusions

Crystal Structure:

In geologic process of formation of gem minerals, gemstone crystallizes in a particular fashion or system depending upon its atomic structure. In a crystalline gemstone, the atoms and molecules of the element or compound it is composed of, positioned in an orderly and symmetrical pattern to give rise to crystal faces, which are external manifestation of an internal structure. As a matter of fact, different gemstones crystallize in different crystal systems when they are formed in the process of cooling of magma. These characteristics of gems form an effective tool for their identification. For example, diamond crystallizes in isometric system, whereas emerald in hexagonal system. There are seven such systems in which the gem minerals crystallize. The gemstones and the system they crystallize are indicated in table- 2.1

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Table 2.1: Crystal symmetry in gemstones

CRYSTAL SYSTEM	GEMSTONE
Isometric or Cubic	Diamond, Garnet, Spinel, Fluorspar
Tetragonal	Zircon, Scapolite, Idocrase, Rutile
Hexagonal	Beryl, Apatite
Trigonal	Ruby, Sapphire, Quartz, Calcite, Tourmaline, Rhodocrosite
Orthorhombic	Adexandrite, Andalusite Chrysoberyl, Iolite, Peridot, Tanzanite, Topaz
Monoclinic	Feldspar (Orthoclase), Kunzite, Nephrite, Jadeite.
Triclinic	Feldspar (Plagioclase), Turquoise, Kyanite, Rhodonite

Apart from crystal systems, the gemstones also crystallize in a particular shape called habit. The gemstones crystallizing in the same system could have different crystal habits, in spite of their similarities in internal crystal structure. The crystal habits of gemstones are also useful for their identification. Some of the gemstones and the habits they crystallize are indicated below:

Table 2.2: Crystal habit of gemstones

CRYSTAL HABIT	GEMSTONE
Acicular	Rutile, Tourmaline in Quartz
Botryoidal	Chalcedony Hematite
Bipyramidal	Sapphire
Columnar	Kyanite, Calcite
Dendritic	Moss Agate
Dodecahedral	Garnet
Euhedral	Diamond, Spinel, Quartz
Mammilliary	Malachite
Massive	Rose Quartz
Octahedral	Diamond, Spinel
Prismatic	Tourmaline, Quartz, Zircon
Schalenohedron	Sapphire
Striations	Tourmaline, Quartz
Tabular	Ruby

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Cleavage, parting and fracture

Many crystalline gem minerals break parallel to certain atomic planes bringing smooth surfaces termed as cleavage planes. The cleavage is always parallel to crystal faces of a particular crystalline form of the gem. The cleavage in described by its quality, perfect, good, imperfect and poor. The cleavage in diamond is perfect octahedral, in calcite it is perfect rhombohedral, in diopside it is imperfect prismatic and in beryl it is poor pinacoidal. Cleavage direction is one of the most important diagnostic character of a gemstone. For example two cleavage directions of spodumene is characteristic to distinguish it from other gems. Cleavage is also another important feature for fashioning of gems especially cleaving diamond.

Parting is breaking of a crystal along planes of structural weaknesses especially along twin planes.

Fracture is the manner in which a crystal breaks other than along cleavage or parting planes. The distinctive type of fractures are, conchoidal, even, granular, splintery etc. Quartz, Chalcedony and Opal break in conchoidal fracture, lapis lazuli in granular, ivory and Nephrite in splintery and serpentine exhibits uneven fracture.

Hardness

The resistance registered by gem minerals to abrasion or scratching is its hardness, which depends on the strength of the bonding faces holding the atom together. Hardness in thus an important property for durability, one of the major attributes of gems. In 1824, the Australian Mineralogist Mohs selected 10 relatively common mineral and averaged them in order of increasing hardness from 1 to 10 as follows.

Mohs' Scale of Hardness

1.	Talc	6.	Orthoclase
2.	Gypsum	7.	Quartz
3.	Calcite	8.	Topaz
4.	Fluorite	9.	Corundum
5.	Apatite	10.	Diamond

Each of these minerals can scratch mineral of lower number, but not the higher one, although two mineral of same hardness can starch each other.

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Specific gravity:

Specific Gravity (SG) is a number expressing the ratio between the weight of a substance to the weight of an equal value of water at 4^{0}C. Specific gravity of gemstone is an important characterizing property of gemstone. The specific gravity of diamond is 3.52, Emerald - 2.72, Ruby - 4.00 and Chrysoberyl - 3.72.

Crystal Chemistry:

We have learnt from the definition of minerals that gem mineral crystallizes in a particular geometric system depending upon its atomic structure of element or compound of elements it is composed of and thus has also got a characteristic chemical composition. In earth's crust, there are ninety elements which form compounds of two or more elements to form minerals. It will be of interest to Gemologists that only eight of these elements from the bulk of the earth crust. Out of these eight, Oxygen and Silicon are dominant elements which combine with other six elements like Aluminium, Iron, Calcium, Magnesium, Potassium and Sodium to form silicate gem minerals like Feldspar and Garnet. Similarly, Oxygen combines with Aluminium and Silicon to form gem minerals like corundum and Quartz respectively.

From gemological point of view, the chemical composition of gemstones could be grouped into four major compositions namely Oxides, Carbonates, Phosphates and Silicates; which could be ascertained from x-ray and chemical analysis of a gem crystal. For example, Beryl and Feldspar represent Gem Silicates, Calcite and Malachite as Gem Carbonates, Apatite and Turquoise as Gem Phosphates and Chrysoberyl and Corundum as Gem Oxides. Interestingly, the chemical composition of gem crystal determines the degree of its durability and hence an essential attribute of a gemstone.

Colour:

Colour is the most characteristic properties of gemstones, which contributes to the beauty of gems. When white light strikes the surface of a gemstone crystal, a part of it is reflected and a part of it refracted into the stone. If none of the reflected and refractive light are absorbed, the stone is clourless and in case of selective absorption of wavelengths, the stone become coloured one. There are eight transition elements; titanium, vanadium, chromium, manganese, Iron, cobalt, nickel and copper. When present in traces in the gem materials, they act as the important colouring agents of gem minerals.

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Corundum which is colourless when in pure state, becomes ruby (red) by presence of traces of chromium and sapphire (blue) by the presence of titanium and Iron, which are significant characteristics colours of corundum species of gem minerals.

TABLE 2.3: Transition elements in coloured gemstones

Transition Elements	Gemstones
Titanium	Blue Sapphire, Blue Zoisite, Kyanite (blue)
Vanadium	Tsavorite, Green Beryl, Tanzanite, green kornerupine, green kyanite, natural & synthetic colour changing sapphire
Chromium	Ruby, Emerald, Chrome dispside, Pink Topaz, Alexandrite, Hiddentie, Dematold garnet, Pyrope garnet, Uvarovite garnet
Manganese	Spessertite garnet, Rhodochrosite, Rhodonite, Andalusite, Morganite, Rose Quartz, Spodumene, Bixbite, Diopside, Kunzite.
Iron	Sapphire, Aquamarine, Blue and Green Tourmaline, Enstatite, Peridot, Iolite, Epidote, yellow Beryls, Diopside, Chrysoberyl Cat's Eye
Cobalt	Synthetic Blue and Green Spinel, Bluish green spinel, synthetic blue quartz, pink Calcite, pink smithsonite, blue cobalt glass
Nickel	Chrysoprase, Sythentic green and yellow sapphire, Peridot (Iron & Nickel), Synthetic Opal
Copper	Diopside, Malachite, Turquoise, Synthetic green sapphire, Azurite, Chrysocolla, Dioptage, Cuprite

Transparency

The absorption of light in a gem material could vary depending upon the nature and thickness of the material. If light is transmitted fully, even if the stone has considerable thickness, the Gem is transparent and if no light is transmitted even on thin gem crystal, the Gemstone is opaque and the intermediate quantum of transmission of light could make the gem translucent. A piece of aquamarine can be transparent and also translucent. Minerals having metallic lustre are mostly opaque, for example Pyrite, The Pyrite mineral has metallic luster and opaque in character.

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Lustre

The lustre of gemstone is the optical effect, created by the reflectivity of the stone surface. Therefore, luster of gem mineral relates to the quality and quantity of light reflected from the surface of the stone and directly related to the RI of Gems. There are two categories of lustre of mineral species, metallic and nonmetallic, out of which gem materials are mostly nonmetallic in character. The nonmetallic lustres are termed as Adamantine, Vitreous, Greasy, Waxy, Dull, Resinous, Silky and Pearly. The gems of different lustres are as follows :

Table 2.4: Lustre shown by gemstones

Lustre	Gemstone
Adamantine	Diamond, Zircon, Demantoid Garnet.
Vitreous	Quartz, Topaz and Corundum
Greasy	Jade
Waxy	Turquoise
Resinous	Amber
Silky	Tiger's Eye, Quartz, Satin spar variety of Gypsum
Pearly	Pearl, Moonstone
Metallic	Pyrite, Galena

Refractive Index

Refractive Index is one the most important optical constant for gemstones, which is governed by Snell's Law in Physics. The Snell' Law states that for the same two media, the ratio of Sin i to Sin r is constant, when i is the angle of incidence and r the angle of refraction. For identification on of gemstone Refractive Index (RI) is most important, which could be determined very accurately.

Chatoyancy

Silky sheen results from closely packed parallel fibres or parallel needle like inclusions or cavities. When such a gem is cut with smooth convex surface (cabochon cut), its surface displays a band of light at right angles to the length of the fibre, inclusions of cavity and when the stone is turned the narrow beams moves from side to side as does a cat's eye and termed chatoyancy or Cat's Eye effect in a gemstone.

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Cat's Eye varieties are found in number of gemstone like chrysoberyl, tourmaline, beryl and Zircon.

Asterism

The Chatoyancy results from inclusions oriented parallel to a single crystallographic direction. If there are three crystallographic directions as in case of hexagonal crystals, the cabochon cut in such a crystal shows a beam of light on its surface perpendicular to each parallel set of inclusions. This triple chatoyancy is called asterism or Star effect and best known in Star rubies and Star Sapphires.

Pleochroism

When light passes through anisotropic crystals, light may be absorbed differently in different vibration directions. Pleochroic colours result from light vibrating at right angles to each other. The absorption in one direction may be nearly complete and at right angles, it may be negligible, resulting pleochroism as in case of tourmaline. In andalusite and zoisite, pleochroism is attractive.

Colour change

White light is composed of even distribution of different wave length of visible light. Thus some artificial fluorescent lighting is deficient in longer wavelengths. Due to this subtle difference in illumination, some gems exhibit significant colour change, for example the chromium coloured variety of chrysobery. Under typical incandescent lamps, alexandrite will exhibit from brownish red to deep purplish red colour, where as in day light it appear bluish green, known as Alexandrite effect.

Adularescence

Light entering some transparent to translucent gemstones is scattered internally by tiny particles or structural irregularities. The scattered light gives the stone a milk sheer or floating light effect called adularescence, For example adularescence of moonstone.

Iridescence

The interference of light reflected from the surface or from the interior of a gem mineral may produce different colours, because of the fact that the angle of incident light changes. Surface iridescence, similar to that produced from soap bubbles, results from interference of light as it is reflected from thin surface films. In case of cut and polished stones, their interference colours are caused by light diffracted

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internally from thin film of liquid, gas or fractures, twin, lamellae, cleavage planes. This is the internal iridescence which produces colour effect in precious opal and some varieties of feldspar.

Labradorescence

A related effect is called as labradorescence or schiller seen is several varieties of feldspar especially in labradorite.

Aventurescence

Some gemstones have relatively coarse and platy crystals of another minerals. When such materials are illuminated by overhead light source, these inclusions may produce giving stone an overall glittery effect known as aventurescence. In nature, a number of gems produce aventurescence like, aventurine quartz, oligoclase feldspar and labradolite feldspar.

Tenebrescence

Tenebrescence is a remarkable property of a few gem minerals which temporarily change their colour. Very few gem minerals exhibit tenebrescence like Hackmanite, a variety of sodalite. The pink coloured sodalite feds to colorless when exposed to light. The sodalite again returns to its original pink colour when it is placed in dark over a period of time or exposed to short wavelengths of ultraviolet light. This transmission is otherwise called as Photochromism.

Inclusions

Most of the gemstones including diamond contain naturally occurring internal characteristics namely inclusions. These inclusions in gemstone is one of the significant feature for identification and evaluation of gemstone. The presence of inclusion pattern in gemstone crystals were established by Dr. EJ Gubelin, which a part from becoming an effective tool in distinguishing natural from synthetic gems, led to the clue of its origin and provenance. The inclusions in gem crystal may be solid, liquid or gas and sometimes may be both liquid and gas. The inclusions could be classified as three basic groups.

1. Protogenetic or pre-existing: These inclusions of minerals present before the formation of host crystals. Foe example, apatite in corundum and Hessonite Garnet and mica in Corundum, Quartz and Emerald, solid inclusions of diamond in Diamond.

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2. Syngenetic or Contemporary: These include mineral inclusions formed contemporaneously along with formation of host crystals. For example, rutile needless in Corundum and quartz and olivine in Diamond.

3. Epigenetic or Post-Contemporary: These represent formations of minerals after the growth of host crystal. For example, development of asterism by exolution of titanium dioxide in Corundum and development of internal cleavage in Topaz and Moonstone.

TABLE- 2.5: Gemstones and their favorite inclusions

Host Gemstone Crystal	**Inclusions**
Hessonite garnet, Ruby, Spinel	Apatite
Emerald, Ruby, Sapphire, Spinel	Calcite
Emerald	Chromite
Diamond	Diamond
Diamond, Corundum	Garnet
Topaz	Hematite
Quartz, Corundum, Emerald	Mica
Diamond	Olivine
Sapphire, Emerald	Pyrite
Ruby	Spinel
Garnet, Corundum	Zircon
Emerald, Aquamarine, Topaz	Quartz
Corundum, Quartz	Rutile
Diamond	Chrome diopside

2.3 Classification of gemstones:

Though the science of gemology is based on the science of Geology, Mineralogy, Chemistry and optical physics, it is deeply related to science of mineralogy. In view of the fact that most of the gems are minerals, it may be prudent to understand the term mineral. According to Cornelius S. Hurlbut and Robert C. Kammerling, (1999) "**a mineral is a naturally occurring crystallized chemical element or compound having**

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either a definite chemical composition or a range in composition and usually formed as a product of inorganic process". Out of 3000 mineral species formed in the earth crust, around 30 reasonably posses the charismatic characteristics of gemstones depending upon their physical, visual and optical properties

Several attempts have been made by Gemmologists to classify gemstones based on their chemical, physical, optical characteristics. A meaningful classification of minerals took shape in the middle of 19th century, based on chemical composition, that segregates the minerals into groups depending upon the dominant anion or anionic group. These mineral groups have not only identical physical and chemical properties but also has resembling mode of origin and occurrence. From geological point of view, apart from diamond, which occurs as native element of carbon, all gemstones are compound of elements and can be classified into four distinct groups of oxides, carbonates, phosphates and silicates as indicated in table 2.6.

Table 2.6 : Classification of Gem Minerals

Chemical Group	**Gemstone**	**Chemical Composition**
Native Element	Diamond	C
Gem Oxides	Chrysoberyl	$BeAl_2O_4$
	Corrundum	Al_2O_3
	Quartz & Chalcedony	SiO_2
	Spinel	$MgO\ Al_2O_3$
GEM CARBONATES	Calcite	$CaCO_3$
	Malachite	$Cu_2(OH)_2\ CO_3$
	Rhodochrosite	$MnCO_3$
GEM PHOSPHATES	Apatite	$Ca\ (F, Cl)\ (PO_4)_3$
	Torquoise	$Cu\ N_6\ (PO_4)_4\ (OH)_8\ 5H_2O$
GEM SILICATES	Beryl	$Be_3Al_2\ (SiO_3)6$
	Feldspar	$KAl\ Si_3\ O8$ $Na\ Al\ Si_3\ O8$ $CaAl_2\ SiO_2\ O8$

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	Garnet	$Mg_3 Al_2 (SiO_4)3$ $Fe_3 Al_2 (Sio_4)3$ $Mn_3 Al_2 (Sio_4)3$ $Ca_3 Al_2 (Sio_4)3$ $Ca_3 Fe_2 (Sio_4)3$ $Ca_3 Cr_2 (Sio_4)3$
	Jadeite	$NaAl(Sio_3)_2$
	Peridot	$(Mg, Fe)_2 SiO_4$
	Rhodonite	$MnSiO_3$
	Topaz	$Al_2 (F,OH)_2 Sio_4$
	Tourmaline	$XR_3 Al_6 B_3 Si_6 O_{27}(OH)_4$ (X = Na, Ca, R = Al, Li, Mg)
	Zircon	$Zr SiO_4$
	Iolite	$(Mg Fe)_2 Al_4 Si_5 O_{18}$

Out of these groups silicate constitute almost 60% of gem mineral, the oxides being the next dominant one. Coming to classification of gemstones, gems are often classified as precious and semiprecious stone based on their value. In the past, Diamond, Ruby, Sapphire, Emerald and Natural Pearls were considered as precious gems and the rest of the gems were considered as semiprecious gems. In view of the fact that there is no rigid criteria that differentiate gems of great value from that of less value, this classification has been discouraged. As a matter of fact a piece of semi precious opal may be more costly than a piece of precious emerald depending upon their gemological qualities. Therefore all gem materials are now being called as gemstones or gems.

In the beginning of the twentieth Century, Brauer (1904), suggested a classification of gemstone depending upon their gemological qualities comprising of hardness, colour, transparency, luster, polishability, rarity, price and market demand. classifying them into five ranks as follow.

a. First rank

The hardness in Moh's scale are between 8 and 10. these are either pure

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carbon or pure alumina or predominantly with alumina such as : diamond, corundum (ruby/sapphire), chrysoberyl and spinel.

b. Second rank

Hardness is 7 to 8 and the specific gravity often over 3. The minerals are silica dominant kinds with value generally lesser than the first rankers but perfect specimens of the second may over ride the first rank in value. Examples are zircon, beryl, emerald, topaz, tourmaline, garnet.

c. Third rank

These are somewhat intermediate between precious and semiprecious stones, with hardness of 6 to 7, specific gravity greater that 2.5 (with exception of turquoise). The value though not very high, a few amongst them e.g. cordierite, chrysolite, turquoise) have considerable value. Specimen with cutting are relatively scares, though others are frequent in availability like, cordierite, idocrase, chrysolite, axinite, kyanite, staurolite, and alusite, chiastolite, epidote and turquoise.

d. Fourth rank

This class goes into the domain of semiprecious stones with hardness of 4 to 7 and specific gravity of 2 to 3. Colour and lustre are their main attractions. Transparent ones fetch good price but the class is often endowed with translucent to edge-transparent gem stones only. The stones are widely distributed and the value is on the lower side naturally. The commonest materials are quartz, chalcedony and opal with all variations besides feldspars like adularia / moonstone, amazon stone or labradorite, obsidian, lapis lazuli, hauynite, hypersthene, diopside, fluorspar etc.

e. Fifth rank

The last rank amongst the gem stones have low hardness and specific gravity and low lustre as well as low transmissions of light within. Needless to say that the prices too are low but often improved conspicuously after lapidary and stone cutting works.. The list includes jet, nephrite, serpentine, agalmatolite, steatite, potstone, diallage, bronzite, bastite / schillerspar, satinspar / gypsum, alabaster, malachite, pyrites, rhodocrosite, hematite, prehnite, cryptomelane, natrolite, lepidolite, lava and agate or quartz breccia etc.

This classification although remained popular for years, all other characteristics remaining same, if a gemstone of certain rank becomes abundant in the market, its

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value depreciate and so also its ranks. Conversely if a gemstone becomes rare in the market, its price rises and so also its rank.

Then came a concept of classifying gemstone into category of Gem Group, Gem species and Gem varieties by the Gemmologists. A Gem Group is defined as two or more Gem species of resembling structure and properties like Feldspar, Garnet and Tourmaline. The Gem species have a definite chemical composition and characteristic crystal structure. The Beryl, Chrysoberyl and Corundum are categorized as gem species. Similarly there are organic gem materials, which are categorized into gem species, like Pearl, Coral, Ivory, Amber. Gemmologically the Gem species could be subdivided into Gem varieties based on their colour, colour distribution, transparency and or optical phenomena. Corundum is a Gem species, the gem mineral composed of aluminium oxide crystallising in hexagonal system. The medium to dark orange red to pigeon blood red variety of corundum is called ruby, where as the blue variety is called sapphire, the other varieties being called as per their color like pink sapphire and yellow sapphire. Similarly Beryl is a Gem species, the gem mineral composed of Beryllium Aluminium Silicate chrystallising in hexagonal system. The medium to dark green variety is called Emerald, light to medium blue variety is called Aquamarine. Pink variety is called Morganite and the yellow variety is called Heliodor. Based on colour distribution, Chalcedony, a fine grained variety of quartz having colour banding of black and white in horizontal plane is called Onyx, where as curved and angular fashion in this stone, it is called Agate. Similarly on transparency, a translucent reddish chalcedony is called Carnelian, where as a red and opaque variety is called Jasper, Some gem minerals exhibits usual optical effects called phenomena such as Star effect or Asterism, Cat's Eye effect or chatoyancy. If a piece of sapphire shows star effect, it is called Star sapphire and if a chrysoberyl shows cat's eye effect, it is called Chrysoberyl Cat's Eye. Based on the concept a possible classification of gemstone is given in Table 2.7.

Table 2.7 : CLASSIFICATIONS OF GEMSTONES

GEM GROUP	GEM SPECIES	GEM VARIETIES
	Beryl	Emerald, Aquamarine, Morganite (pink), Heliodor (Yellow), Goshenite (Colourless)
	Chrysoberyl	Chroysoberyl, Chrysoberyl Cat's Eye, Alexandrite, Alexandrite Cat' Eye

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	Corundum	Ruby, Star ruby, Sapphire, pink Sapphire, violet Sapphire, green Sapphire.
Feldspar	Orthoclase	Moonstone (yellow, colourless), Orthoclase with iridescence)
	Microcline	Amazonstone (Green)
	Plagioclase	Labradolite (Multicolour shaded yellow)
	Diamond	Diamond (Colourless), Diamond (Blue)
Garnet	Almandine	Almandine (Purplish red)
	Pyrope	Pyrope (Deep Blood red)
	Rhodolite	Rhodolite (Purple)
	Spessartite	Spessartite (orange, yellow, flame red)
	Glossularite	Hessonite (medium to dark orange, brown orange to brownish yellow), Tsavorite (medium light green to yellowish green)
	Andradite	Topazolite (Yellow), Demantiod (Green)
	Uvarovite	Uvarovite (Green)
	Iolite	Iolite (Blue to violet blue)
	Jadeite	Jade (Emerald green, dull green, mauve, lavender, yellow, brown)
	Lazurite	Lapis Lazuli- a rock composed of lazurite, hauynite, sodalite, noselite with pyrite inclusions (blue, greenish to purple blue)
	Opal	White opal, black opal, fire opal
	Peridot	Peridot (Olive green to shades of green)
	Quartz (Crystalline)	Amethyst (Purple), Citrine (Yellow), Rock crystal (colourless), Rose quartz (Pink), Aventurine (Green)

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	Quartz cat's eye	(Crystalline) Quartz cat's-eye, Tiger's eye (Golden brown), Hawk's eye (Blue)
	Quartz (Cryptocrystalline)	Chalcedony (unbanded), Carnelian (Red), Chrysoprase (apple green), Agate (Concentric bands), Onyx (Straight bands), moss agate (dendritic growth)
	Spinel	Spinel in all colour ranges, also colour changing type
	Spodumene	Hiddenite (Pale green to bluish green), Kunzite (Pink, Violet)
	Topaz	Topaz- colourless, blue, yellow, pink, orange, brown
	Tourmaline	Rubellite (Pink to red), Indicolite (deep pinky blue), Achroite (Colourless), Schorl (black), Liddicoatite (brown, blue, or pink/green parti coloured)
	Turquoise	Turquoise (Blue to green to yellow green)
	Zircon	Zircon- Colourless, blue, orange, red, yellow, golden brown, green
	Zoisite	Tanzanite (Blue), Thulite (massive pink), Anyolite (green with translucent rubies)
	Pearl	Natural pearl, cultured pearl
	Coral	Coral- pink, red, orange, black
	Ivory	Ivory
	Amber	Amber

Coming back to the definition of gemology, the science of gemology covers not only the science of gemology, geology, chemistry and physics, but also overlaps into the science of zoology, botany and marine biology, which apart from minerals also accommodate the gems formed by organic process. Therefore, the entire spectrum

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of gemstone is broadly classified as inorganic and organic Gems based on their genetic relationship. The inorganic gems are naturally occurring minerals formed by geologic process and the organic gems are formed by biogenic process. They are classified as follows :

Table 2.8 Classification of Gemstone

INORGANIC GEMS	ORGANIC GEMS
Beryl	Pearl
Chrysoberyl	Coral
Corundum	Ivory
Diamond	Amber
Feldspar	Jet
Garnet	Shell
Iolite	
Jade	
Lapis lazuli	
Opal	
Peridot	
Quartz	
Spinel	
Spodumene	
Topaz	
Tourmaline	
Turquoise	
Zircon	
Zoisite	

2.4 Synthetic gemstones and gemstone simulants

The beauty, and rarity of natural gemstone have always lured mankind to duplicate them. The knowledge of gemstone of man and his pursuit to imitate gemstones have been almost contemporaneous. In 4000 BC the manufacture of synthetic gems commenced when beads of blue glazed steatite were made to imitate Lapis Lazuli. The efforts made by man in this direction have resulted in synthesizing gemstones in the laboratory, when French Chemist Gaudin (1837) succeeded in synthesizing a small crystal of ruby and Frenchman Fremy (1887) produced large

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number of small crystals of rubies, which prompted production of synthetic gemstones worldwide.

When a man made gemstone possesses the physical, chemical and optical properties of its natural counterpart, it is called **Synthetic** gemstone. The characteristics of synthetic gemstones being exactly similar to those of natural ones, it is more difficult for a gemologists to distinguish them so much so that they have to harp on some minute internal features in a gem crystal to diagnose them.

In early twentieth century, the gem crystals of synthetic Spinel (1926), synthetic Ruby (1934) and synthetic Emerald (1940) were produced. The synthetic gems were produced by developing several process technologies which includes:

(a) Verneuil Flame Fusion process

(b) Czochralski method

(c) Flux Melt grown method

(d) Hydrothermal process

(e) Skull Crucible process

(f) Diamond synthesis method.

By adopting these technologies, countries like USA, UK, Germany, Russia, France, Japan and China produced some rare varieties of gemstones in commercial scale such as Alexandrite, Amethyst, Diamond, Emerald, Ruby, Opal and Spinel. Opal has been produced by Australian scientist Gaskin, but large scale production could be done by Frenchman Gilson.

Similarly when a man made gemstone resembles a natural gemstone in its colour and look but differ from physical, optical and chemical properties of the natural gemstone it resembles, is called **imitation** or **simulant**. For example. Synthetic Cubic Zirconia (CZ) resembles a natural diamond and popularly known as American diamond, but differs in physical, chemical,and optical properties of natural diamond and called as Diamond stimulant, but not synthetic diamond. Besides, colourless varieties of natural stones like Quartz, Topaz, Corundum and Zircon are also included in the simulants of Diamond. For coloured gemstones: synthetric Corundum and Spinel are produced to imitate characteristic colour change in Alexandrite, synthetic blue Spinel for imitating Aquamarine and a variety of blue synthetic Fosterite to imitate Tanzanite. Glass is also used as the cheapest mode of gemstone simulant. In 1985, an attractive piece of blue aquamarine purchased by Odisha Mining Corporation from Balangir district of Odisha, when put to auction sale at Jaipur was detracted by

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the buyers. Later on, when it was put to testing in a gemological laboratory, it was identified as nothing but glass.

Gemstone enhancement

The treatment and enhancement of gemstones has been tried by man since time immemorial, may be natural and synthetic gems, to enhance their colour for value addition. There has been recent development to adopt some sophisticated process technologies to enhance the colour of gems, the most common process being heat treatment and irradiation mostly practiced in Bangkok. Gemstones like green and light blue Aquamarine on heat treatment can become blue Aquamarine, yellow and yellow brown Topaz becomes pink Topaz, dark green Tourmaline can become emerald green Aquamarine and pink Amethyst can become rare varieties of yellow, orange of gold colour citrine. Similarly, the process of irradiation techniques poundiing materials with sub-atomic particles or radiation is applied to enhance the colour of gemstone. The process of irradiation followed by heat treatment is adopted for enhancing the colour of blue Topaz. Off coloured Diamonds are irradiated to produce rare variety of blue and pink Diamonds. Cultured pearls are irradiated to produce blue and grey coloured pearls.

The exodus of synthetic gemstone and their simulants in gemstone market have baffled the gemologists for years, for which the science of Gemmology has to be developed and relied upon for their apt identification and value.

2.5 Organic gem and their simulants

Many of the attractive and beautiful materials, those have been valued as gems and ornamental stones, are created by organic process rather than by inquimate geologic process. These gem materials include Amber, Coral, Ivory, Jet, Pearl, Sheel and Tortoise shell. In science of gemology, they occupy an important place as organic gems. The study of their gemological characters have no doubt enriched the science of gemology. These Organic gems vary from the inorganic variety as they are the product of living organisms formed by biologic process. Out of these, only amber is composed of organic substance, the rest being composed partially of inorganic substance. With exception of Coral and Pearl, these materials are also noncrystalline, which distinguishes them from most of the inorganic gems, which are crystalline in nature. The chemical composition of these gem species also vary perceptibly depending upon their origin, colour and age.

Amber:

Amber is mostly a pale yellow brown translucent to opaque gem material but also found in reddish brown, greenish, bluish grey and black varieties. The gems have

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SG of 1.08. R 1 to 1.54 and hardness ranging from 2.0- 2.5. These are fashioned to make necklace and bracelets and other ornaments used since Neolithic time. Amber is a form of fossilized resin extruded from trees of million years ago, which has been hardened and transformed into tough solid, through a process of oxidation, loss of volatiles and sometimes long spam of burial. The fossilized tree resins contain a mixture of hydrocarbons and succinic acid and consist mainly of carbon (79%), Hydrogen (10%) and Oxygen (11%). Although Amber is formed in many localities, most of the world's amber comes from the Southern coast of the Baltic Sea region, which has luxuriant forest growth of resin bearing trees. In view of its low density, it travels from beaches to beaches by wave action and in low tide it gets separated from the sea weed. These types are called Sea Amber. The amber bearing deposits from which the sea ambers are washed away are mined by open pit method and called as Pit amber.

Organic gems which are product of living organisms have many stimulants. Among many amber imitations, Copal resin and Kauri Gum (From Kauri tree in New Zealand) are most convincing stimulants.

Coral:

Coral is a popular gem material used by man. This is fashioned as necklace beads. The use of red corals dates back to Mesopotamian civilization (3000 BC). Coral is formed mainly of calcium carbonate, magnesium carbonate and proteinaceous organic substance. The branched and plant shaped structure of coral is formed from Calcareous skeleton of colonies of marine organisms living in shallow subtropical clear warm waters of Mediterrean sea. Corals made their appearance 500 million years ago and since then many different forms of corals have been developed, out of which two major types are used as gem materials; Precious coral, Corallium rubrum and Black Coral. Corallium nigrum. The precious corals are mainly white, pink, red and dark red in colour, where as the black coral, which is composed of conchiolin, an organic protein material, in dark brown to black in colour. The SG of white and pink coral in 2.6 to 2.84, where as for black Coral it is 1.34- 1.46. In view of coral growing in warm waters, most species are confined to equatorial zone between Latitude 30° N to 25° S.

There are many Coral stimulants which include plastics, pink-stained vegetable ivory and stained bone.

Ivory:

The ornaments made of ivory are round beaded necklace and bangles faceted from the ivory and popular since Thirteenth century AD. The major source of ivory

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is Dentine ivory, which comes from the tusks of the elephant, elongated canine teeth of walrus and large canine teeth of Hippopotamus. Some ivory comes from the tusks of fossilized mammoth that lived in glacial period also. The front horn like tooth of Narwhal, (a dolphin like artic whale) and the teeth of sperm whale also constitute the source of ivory. The RI of ivory is around 1.54 and SG of 1.7- 2.0.

The most convincing ivory stimulant is cellulold.

Jet:

Jet is a gem material used for carving, beads, pedants and known as Victorian mourning jewellery. This is a form of fossilized wood, which is carboniferous in composition and contains traces of mineral elements like aluminium, silicon and sulphur and mineral oil. Jet is similar to lignite or brown coal and like coal, is a fossilized wood that was first altered chemically by surface water and later physically by pressure emanating from deep burial for a long span of time. The Jet has a hardness of 2.5-4.0, SG of 1.3-1.4 and RI of 1.6-1.68.

Anthracite, a compact non-bituminous type of coal, is a common stimulant of jet.

Natural pearl:

Out of all organic gems, pearls are the most adornable and popular one used as beads in necklace and pedants. Pearl is formed inside a pearl mollusc or oyster, as a result of parasitic larvae penetrating the creature's shell and causing an irritation or infection. The mollusk reacts to the local inflammation by surrounding the sale of irritation with sac of cells with self defense called the mantle or pallium. This sac mantle tissue secrets a concentric layers of deposit, which encapsules the intruding larvae with concentric layers of nacre. The nacreaous deposit consist of a very thin cellular network of conchiolin, whose interstices are filled with aragonite. The mollusc those have nacreous mother of pearl lining can only from pearls. Once a mollusc or oyster has enclosed a source of irritation with nacre., it continues to deposit further layers for 7 years. This has got a composition of calcium carbonate (86%) Conchiolin (12%) and water (2%). The Principal attraction of pearl lies in its irridescent sheen, as a result of a combination of interference and diffraction effects in the thin surface layers of the gems and known as orient. Most of the pearls are silver white, but some species are pink and black in colour. The SG for natural pearl is 2.68-2.78 and RI 1.52-1.69.

The most valuable of organic gems being pearl, have three types of stimulants, such as hollow glass sphere filled with glass, solid sphere of glass or plastic and soild mother of pearl sphere, the most being solid sphere of plastic.

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Cultured Pearl:

Although attempt made by Man to Cultivate this popular gems dates back to 1900 AD, more recently Tokichi Nishikawa's 'Piece' technique have been widely used by Kokichi Mikimoto and others to produce spherical cultured pearls. This method involves inserting 5-7 mm diameter mother of pearl bead and a cube of mantle tissue into a 3 year old mollusc and left in the sea. Three years later the mollusc is collected and the mother of pearl bead being transformed into cultured pearl with 1-2 mm layer of nacre is extracted from the mollusc. The SG of cultural pearl is slightly higher than of natural pearl being 2.74 gm/cm2, which distinguishes them.

Shell:

The shells those produce pearls as their inner surfaces are composed of mother of pearl that displays the same luster as the pearls themselves and are widely used as ornamental materials. These gem materials are fashioned as cameos and intalgios. There are varieties of ornamental shells like the shell of the Haliotis mollusc being colourful with banned growth contours, Cameo shells with a brown underlying layer and shells with underlying orange colour, Helmet shell having two or more contrasting layers of colour shade, which produces ornaments and costume jewellery.

Plastics imitations are commonly used to imitate shell.

Tortoise Shell:

Tortoise shell is an organic gem material with an attractive mottled look and composed of Keratin, mostly salvased from the outershell of Hawksbill sea Turtle. The shell used for ornamental purpose are the upper shell known as carapace, which consist of 13 overlapping plates known as blades. This is typically mottled yellow and brown in colour. The RI of Tortoise shell is around 1.55 and the SG being around 1.29.

The plastics including casein are used to imitate tortoise shell.

2.6 Fashioning of gemstone

Although man has smelted and shaped minerals since beginning of Stone age for making tools and weapons, it is only in the Fag end of the Stone age, man tried to shape and polish minerals for enhancement of their beauty. The inscriptions in the tombs of ancient Egypt built 5000 years before, depicts the craftsmanship of man fashioning Malachite and Lapis Lazuli consummately. But the consummate techniques of cutting and polishing of both Diamond and coloured stones have been developed over the years beginning from the Fourteenth century to bring marvel and brilliance in a rough gemstone with concomitant development of the science of gemology. The style and techniques of fashioning of a piece of gemstone largely

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depends upon the size, shape and the gemmological characteristics it possesses. The cutting and polishing of gemstones have been classified into three categories:

(a) Cabochon cut, (b) Facet cut and (c) Carved and engraved.

The techniques of cutting however largely depends upon the nature of gemstones to be fashioned. The opaque and translucent gems are mostly fashioned as cabochon cut, where as transparent gems are fashioned as facet cut. The opaque and massive gems are carved and engraved to unravels its beauty.

The cabochon cuts are made by way of shaping gems into rounded surfaces and then polishing them optimally. The styles of cabochons are again sub-divided into three types depending upon the gemological characteristics of gemstones such as:

(a) Simple cabochon cut, (b) Double cabochon cut and (c) Hollow cabochon cut

But common cabochon cuts are rounded top having flat base. Gemstone beads are fashioned by adopting cabochon cuts from gemstones like Jade, Chalcedony, Turquoise and Malachite. The gemstones having optical phenomena like Star Rubies, Star Sapphires, Chrysoberyl Cat's eye and Alexandrite Cat's eye are also fashioned as cabochon cuts with an express purpose of keeping its optical phenomena of chatoyancy or asterism intact.

Similarly, transparent gemstones are put to facet cuts in order to enhance their beauty, brilliance and symmetry. The degree of brilliance of a transparent gemstone could be achieved by way of facet cut, which again largely depends upon its refractive index, critical angle and total internal reflection apart from physical properties like crystal symmetry.

There are four different styles of facet cut adopted for fashioning of gemstones depending upon its properties and dimensions such as;

(a) Brilliant cut, (b) Emerald cut, (c) Rose cut and (d) Table cut

Brilliant cuts are mostly done for fashioning of diamond, the rest cutting styles being adopted for fashioning of coloured gemstone based on its gemological parameters. In case of Diamond, 4 C parameters like colour, clarity, carat weight and cut are taken into account for its valuation and hence selection of cutting style is important for value addition. The coloured gemstones after cutting and shaping are subjected to polishing in a lapidary, where as cutting and polishing of Diamond is done by cutting specialists for enhancement of its beauty and brilliance.

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CHAPTER III

GEOLOGY OF GEMSTONES

3.1 INTRODUCTION

Gemstones are basically minerals crystallized in the process of formation of igneous, sedimentary and metamorphic rocks in the Earth's Crust. Therefore, the geology of gemstones is genetically related to the geology of Earth's Crust. The study of the structure of Earth depicts that the Earth consists of three zones, a central Core, an Intermediate Mantle and an outer Crust. The Central core has a diameter of 7000 km. and consist of two zones, outer core and inner core. The outer core is composed of a liquid mass called magma and has a thickness of 2100 km. and the inner core is composed of solid dense rock having a diameter of 2700 Km. The Intermediate mantle is a semi molten zone in between the core and the outer crust having a thickness of 2900 km. Above the mantle lies a solidified crust having a thickness varying from 5 Km to 72 km, which happens to be the source of occurrence of gem minerals in different igneous, sedimentary and metamorphic rocks and their derivatives.

The Geology of Earth's Crust, which involves process of formation of igneous, sedimentary and metamorphic rocks over hundreds of million years depicts the mode of formation of minerals and as well as the geology of gem minerals. The geochemistry of the Earth's Crust reveals that out of 90 natural elements in the Earth's Crust, there are 30 elements which are responsible for formation of major rock forming minerals including feldspar, quartz, pyroxene, amphibole, mica, olivine and also gem minerals. Similarly out of 3000 minerals, only around 30 having one or more than one gemmological characteristics are termed as gemstones. There are 21 basic elements, which compound to form gem minerals in natural state. In the process of formation of such minerals, there are also 21 rare or transition elements, the concentration of which in certain geologic environment could form gem minerals having fascinating and attractive colours and other gemmological characteristics.

Corundum is a Gem species, which gives two important Gem varieties, Ruby and Sapphire. The chemical composition of Corundum (Al_2O_3) is Aluminum oxide. The Purple red colour of ruby is due to the presence of rare element of chromium replacing aluminum in the crystal structure, where as blue colour of sapphire is due

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to the presence of rare element of iron and titanium in the same geological environment of metamorphic recrystallisation. Similarly the native element of carbon, which is the sole constituent element of diamond form colourless diamond in apt geologic conditions. The concentration of rare element of nitrogen makes the diamond slightly yellow in colour, whereas concentration of rare element of boron makes the diamond blue in colour in process of formation in Kimberlitic or Lamphroitic pipes in plutonic environment. The list of such 21 basic elements and 21 transition elements responsible for formation of gem minerals are given in Table 3.1.

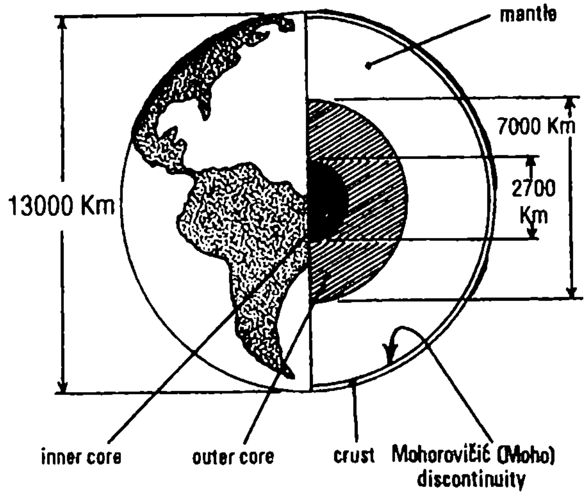

TABLE 3.1 : ABUNDANCE OF ELEMENTS OF GEM FORMING MINERALS IN EARTH'S CRUST

Sl. No.	Basic Elements			Rare Elements		
	Basic Elements	Symbol	WT%	Rare Elements	Symbol	WT%
1	Oxygen	O	6.60	Aluminium	Al	8.13
2	Silicon	Si	27.72	Iron	Fe	5.00
3	Aluminium	Al	8.13	Calcium	Cao	3.63
4	Iron	Fe	5.00	Magnesium	Mg	2.09
5	Calcium	Ca	3.63	Titanium	Tl	0.44
6	Sodium	Na	2.83	Phosphorus	P	0.10
7	Potassium	K	2.59	Manganese	Mn	0.09

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8	Magnesium	Mg	2.09	Fluorine	F	0.063
9	Hydrogen	H	0.14	Vanadium	V	0.014
10	Phosphorus	P	0.10	Chromium	Cr	0.010
11	Manganese	Mn	0.09	Nickel	Ni	0.008
12	Fluorine	F	0.063	Zinc	Zn	0.0065
13	Sulpher	S	0.026	Copper	Cu	0.0055
14	Carbon	C	0.020	Cobalt	Co	0.0025
15	Zirconium	Zr	0.017	Lithium	LI	0.0020
16	Chlorine	Cl	0.013	Nitrogen	N	0.0020
17	Chromium	Cr	0.010	Boron	B	0.0010
18	Copper	Cu	0.0055	Thorium	Th	0.0007
19	Lithium	LI	0.0020	Cesium	Cs	0.0003
20	Boron	B	0.0010	Beryllium	Be	0.00028
21	Beryllium	Be	0.00028	Uranium	U	0.00018

The selective absorption of light in most of the gemstones are caused by either concentration of rare elements as impurities or in their chemical composition which displays various shades of colour. The gemstones whose colour is caused by impurities are called as allochromatic, where as in case the colour is caused by their own chemical composition are called as idiochromatic gemstones. The major gem minerals are allochromatic and when in pure state are colourless like rock crystal, colourless sapphire, topaz and diamond. In allochromatic gems, the rare / transition elements act as colouring impurities, where as in idiochromatic gemstone, they form an integral part of the chemical composition of the gem minerals. Spodumene is Lithium Aluminium Silicate, which is allochromatic. The presence of transition element of manganese in spodumene makes it pinkish red kunzite, where as presence of iron makes it yellow to green hiddenite. Similarly Rhodochrosite is an idiochromatic gemstone. The colour shades of Rhodochrosites are formed by replacement of manganese by calcium, iron, zinc and magnesium in the mineral compound itself. The major transition elements, which acts as an colouring agent in process of formation of gemstones in the earth crust are given in Table 2.3 in Chapter II.

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3.2 ORIGIN AND OCCURRENCE OF GEMSTONE

The rocks of the Earth's Crust are divided into three major groups, igneous, metamorphic and sedimentary depending upon their mode of origin. They occur as three distinct layers in the crust, the top thin layer as sedimentary rocks and the middle and lower layer as igneous rocks. The sedimentary and igneous rocks in certain areas of the crust have undergone changes due to increasing temperature, pressure and occur as metamorphic rocks. The origin of gemstones can be attributed to the igneous, metamorphic and sedimentary processes of rock formation and the pneumatolitic and hydrothermal solutions emanating in these processes. The mode of occurrence of gem deposits are mostly related to their mode of origin and therefore depends upon the geologic process by which they are formed. The Origin of gemstones as a result could be categorized as;

- Gemstones of Igneous origin
- Gemstones of Metamorphic origin
- Gemstones of Sedimentary origin

3.2.1 GEMSTONES OF IGNEOUS ORIGIN

The Igneous or magmatic process of formation of rocks involve cooling and solidification of molten magma, a molten silicate mass containing many volatile compounds in solution. This molten mass, which happens to occupy in certain sector of the earth's crust, when erupts to the surface of the crust through volcanic Pipes, releases its volatile compounds to the atmosphere and solidifies as lava due to rapid cooling of the magma. This is known as Volcanic or Extrusive rocks like rhyolite, basalt and trachytes. In the process of formation of these rocks gemstones of several varieties including, beryl, chrysoberyl, chalcedony, corundum, diamond, feldspar, pyrope, garnet, peridot, quartz, spodumene and topaz are formed. The gemstone deposits of igneous Origin can also be grouped into four types depending upon their mode of Origin. They are;

- Volcanic Gems Deposit
- Magmatic Gems Deposit
- Pegmatitic Gems Deposit
- Hydrothermal Gems Deposit.

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Volcanic gem deposits:

The molten lava erupting from fissures or pipes on the Earth's crust comes as a source of gem minerals, which may be categorized as volcanic gems deposit. These volcanogenic deposits may be formed and found to occur in two modes)'

(i) Gemstones as an integral constituent of hot lava, which crystallizes as such when the lava cools rapidly in surface of the crust. For example- Moonstone.

(ii) Gemstones deposited in lithophysical cavities formed in process of cooling and evaporation of volatiles in the surface of the crust in the end phase of cooling. For example Chalcedony, Amethyst etc.

The moonstone deposits of significance occur in feldspar rich dykes near Ambalangoda in Southern Province and Kandy in Central Province of Sri Lanka as an upper mantle deposit and form an important source of moonstone in the world. In India, reddish brown moonstone of the similar origin also occur in Coimbatore district of Tamilnadu state (Webster, 1975). The upper mantle deposit associated with lava flow is also significant in Peridot deposit of Peridot Mesa, San Carlos, Arizona, USA. Peridot Mesa is capped by basalt believed to have been erupted from Volcanic core that occurs in the south west corner of Peridot Mesa. The olivine bombs spread out in the region are mostly rounded and granular containing irregular fragments of peridot upto 2 cm diameter and happens to be a potential source of supply to the World market (Koivula, 1981).

Regarding gemstones formed in lithophysical cavities of cooling lava on the surface of the earth, the best example will be the chalcedony and amethyst deposits formed in amygdaloidal cavities of the lava in Decan Traps of Peninsular India, which form an invaluable source of gem quality amethyst and chalcedony.

Magmatic gem deposits:

For want of passage to the surface of the Earth's crust, the magmatic mass cools very slowly and solidifies in the middle and lower layer of the crust, leading to the formation of crystalline rocks composed of large crystals of constituent minerals. These rocks are formed at a temperature from 800^0-1000^0C called as Extrusive or plutonic rocks like granite, gabbro and syenite. Most important primary gem minerals including quartz, feldspar, Pyrope garnet, Sapphire, ruby, zircon and diamond are formed in the process of fractional crystalistion of solidifying magma in plutonic environment and can be categorised as Magmatic Gems deposit.

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The gemstones crystallising in greater depth in plutonic environment may be carried away to the surface by the erupting magma like alkali basalts bringing peridot, zircon, sapphire and more prudently diamondiferous kimberlite pipes bringing diamond to the surface of the crust. But more commonly these gem minerals are recovered from their occurrences as sedimentary deposits after the process of weathering has released them from the rocks in which they are formed. In case the rock mass could withstand the weathering process and the concentration of gem minerals are in the rock mass is rich and within minable limit, the rock itself could be mined as such. For example, the sapphires are mined from a dyke of Igneous rock in Yogo Gulch, Montana, USA. The Yogo Gulch deposit in Central Montana is the world's major deposits of Sapphire, which occur in the in situ igneous rocks of lamprophyre. Since 1980 Yugo Gulch mines produces Sapphire having a commercial identity as 'Royal American Sapphire'.

The most glaring example of plutonic gems deposits occur on Chanthaburi - Tract province of Thailand, which occurs as alluvial and eluvial deposits derived from underlying basalts known as Chanthaburi - Tract basalt (Vichit, 1978). The olivine bearing alkaline basalt of Chanthaburi has undergone both chemical and mechanical weathering typical of tropical climate enriching blue, blue green, yellow sapphire and black star sapphire around Khao Ploi Waen and Bang Kha Cha of Chanthaburi province, which is the principal supplier of sapphire to the world market at present. Besides in similar geological conditions, in the East of Chanthaburi occurrences of ruby and sapphire are there at BoRai, Bo Waen of Tract Province which extend to Pailin deposit of ruby in Kampuchea. Bo Rai, Bo Waen together with Pailin produces bulk of the ruby at present.

As per Jobbins and Berrange (1981), during the Himalayan origin of early to middle Tertiary period, the region has largely been underlain by Jurassic - Triassic sandstone and devonian phyllites. During the final stage of this Orogenic activities, the area is also intruded by basaltic dykes that spilled into Earth surfaces in form of extensive basalting lava flow. Since that period of mountain building and volcanic activity, the region has been geologically quiet and the surface has been exposed to intense weathering and erosion and redeposited as deep residual soil horizon enriching secondary gems deposits of significance as placer deposits derived from the hypobasal plutonic deposit.

It would be prudent to discuss the origin of diamond as this stage as it is originated basically in magmatic environment of igneous activity, although not exactly

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in the domain of crust of the earth but in between the crust and the mantle or may be in both. It is believed that diamonds have been formed in a transitional zone between lower part of the crust and beginning of the mantle known as Mohorovicic Discontinuity or Moho, which is named after Yugoslovian Professor, who discovered the same. As per the current theory, diamonds have been crystallised at 200 kilometers beneath the surface of the Earth from Carbon in form of Carbon dioxide or Methane at very high pressure and temperature, probably reaching 70,000 Kg/Cm2 and temperature of 2000^{0}C respectively, the conditions conducive for the formation of diamonds confined to upper mantle consisting of ultramafic rocks. The diamond bearing magma has been presumably forced to the surface of the crust by explosive volcanic event, which was cooled rapidly and solidified to form Kimberlite or lamphroite pipes as the case may be which represents the bulk of the primary diamond deposits of the world.

The deposits are in form of narrow vertical tubes called pipe, which spreads out into cone or carrot shape near the surface. The diamondiferous Kimberlite or Lamphroite pipes contain broken and rounded fragments of solid rock both from mantle and the crust. Diamond are found to occur as single crystal embedded in the volcanic kimberlitic on Lamphroitic matrix of an alkaline ultrabasic rocks.

The primary diamond was first discovered in 1979 in the classical kimberlite pipe of the Kimberley region of South Africa having poorest concentration of diamond, may be 100 tonnes of diamond bearing materials yielding 10 carats of diamond, out of which 3.5 carats are of gem quality. The most of the known kimberlite pipes of Africa and South America were formed during Cretaceous period between 70 millions and 150 millions years ago which is contemporaneous with the beginning of the continental drift, the phenomenal dislocation that has separated South America, Africa and created Atlantic Ocean as well.

The Argyle diamondiferous lamphroite pipe is the richest Pipe in the world situated in Kimberly region of West Australia. It is significant in the sense that it has changed the very perception of geologistst that diamonds are only confined to Kimberlites. After the discovery of this pipe, the Geologists have started scanning the lamphroite pipes encountered in the other part of the world for its diamond association.

DOW and GEMUTS (1969) have described the geology of Argyle pipe. The Argyle pipe is located in a major tectonic feature known as Halls Creek Mobile Zone,

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a 400 km long N - NE trending belt of deformed Precarnbrian metamorphic, Igneous and sedimentary rocks. The Argyle lamphroites pipe have intruded into the sedimentary rocks, which is controlled by the tectonic evolution of the mobile belt especially faulting. The pipe itself is an elongated bowl shaped body of 2 Km length in N- S direction and its width varying for 500 M at the Northern tip to 150 M in the Southern tip. Petrographically, the Argyle pipe is Olivine Lamphroite, the age of which has been determined 1048 and 1253 million years and of its host sedimentary shale as 1057 and 1158 million years, which were almost contemporaneous (Keller, 1989.) The Production of diamond in Argyle commenced in 1986 producing 30 million carats, out of which hardly 5% of the total production are of gem quality.

Pegmatitic gem deposit

As a result of crystallization in magma, the volatile component being unable to escape into surface, tend to accumulate in the magma chamber with increasing volume and pressure as pneumatolitic fluid having concentration of some rare transition elements also. The transition elements include, Beryllium, Lithium, Boron, Manganese, Phosphorus, Fluorine and Cesium. The semisolid magma enriched with volatiles and rare elements flows up from the magma and get injected into the fractures in the pre-existing country rocks. In process of cooling of Pneumatolitic fluid, coarse grained Pegmatites are formed with large crystals of gem minerals in end phase of crystallizing magma, which includes large deposits of beryl, tourmaline, chrysoberyl, spodumene (Kunzite), topaz and many other varieties of gems as well.

Henrich (1956) classified Pegmatites into three types based on their internal structure.

(i) **Simple pegmatites** that consist only of quartz, feldspar and mica and exhibit an internal structure.

(ii) **Zoned pegmatites** that consist of not only quartz, feldspar and mica but also a variety of accessory minerals. These minerals exhibit zoning with crystal size increasing towards the core of the pegmatite. The zones or layer include the border, wall, intermediate and core zones. The concentration of gemstone may be in the core or Intermediate zones.

(iii) **Complex pegmatite** those are very similar to zoned pegmatites, but have undergone extensive alteration. They often contain an extensive array of rare minerals including gemstones that may form an irregular openings or pockets, which may vary greatly in size upto several meters. The pockets are found in the central core or at the edge of the core and the intermediate zone.

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More recently attempts have been made to classify pegmatites based on the depth they are formed (Cerny, 1982) as follows;

(i) Those formed at depths greater than 11 km, which tend to be unzoned and consist of only quartz, feldspar and mica.

(ii) Pegmatite formed at depths between 7 and 11 km, which may be zoned but are still of basic composition.

(iii) Pegmatite formed at depths between 3.5 to 7 Km, which may be zoned and contain rare minerals and pockets of small crystals.

(iv) Pegmatite formed at depths less than 3.5 Km, which are zoned and may contain larger crystals and pocket of rare minerals including gemstones.

This classification of pegmatites suggest that pegmatities formed in shallow depths of the Earth's Crust in the fourth category are of gemological importance, where a typical geological environment leads to the concentration of rare elements and subsequent formation of gem minerals.

The concentration of rare elements of beryllium, chromium and vanadium in beryl forms gemstones like green emerald, blue aquamarine, pink to orange morganite, yellow golden beryl and green beryl, concentration of rare elements like boron and lithium in tourmaline forms various shades of green, yellow, red and blue tourmaline, concentration of lithium in spodumene forms colourless and yellow crystal of spodumene, concentration of manganese in spodumene forms Pink Kunzite and concentration of Iron in spodumene forms green hiddenite, the concentration of fluorine in topaz forms colourless or coloured Yellow, Orange, Brown, Red, Pink, Blue and Green Crystals of topaz and concentration of beryllium, Iron and chromium in chrysoberyl forms yellow, green - brown crystals of Chrysoberyl and Pink Alexandrite.

Besides, Quartz and feldspars species are typical of pegmatites consisting of varieties of gem minerals. The rose quartz, yellow citrine, green amazon stone and adularescent moonstone are significant gem verities of quartz species and feldspar group derived from pegmatites.

Gems minerals are mostly enriched in zoned and complex pegmatites formed from granitic magma at shallow depth. Granitic Pegmatites are wide spread world wide, but only a small percentage are gem bearing. The world's most important gem producing pegmatites are in the state of Minas Gerais, Brazil, which has produced more of tourmaline, topaz, kunzite, morganite, aquamarine and chrysoberyl than

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rest of the pegmatites of the world. The geological study by Dirac and Ebert (1967) reveals that the gem bearing pegmatites have been formed 490 billion years ago. During this time the pegmatitic fluid and granitic magmas domed and fractured the overlying rocks and dissipated into passages as a result of which cooling process commenced and with time passed of, these fluids cooled and crystallized to form dykes in older metamorphic rocks. The subsequent weathering and rapid erosion, the pegmatites have exposed more resistant minerals including gemstone.

Hydrothermal gem deposit

The Pegmatitic phase with progressive cooling of the magma passes into hot water or hydrothermal phases containing many chemical constituents including rare elements in solutions. In event of upward migration of the solutions into a cooling environment, naturally the hydrothermal solutions cool as they travel away from the source and as a result many minerals are crystallised in a temperature ranging from 50^0 - 500^0C including some interesting gem minerals like amethyst, topaz, beryl and emerald.

The most characteristic mode of hydrothermal deposits are vein deposits in fissures, which requires the formation of fissures itself followed by mineralization to fill the fissures over a period of time. The hydrothermal vein minerals usually represent the type of rocks the fluid has passed through and the type of magma from which the solutions have originated.

In the process of crystallization of hydrothermal fluid, many gemstone deposits have been formed including striking Amethyst deposit of Mursinka district in Ural Mountains, former USSR, topaz deposit of Ouro Preto, Brazil (Olsen D. R. 1971) and most significantly Muzo and Chivor Emerald deposits of Columbia, which are worth discussing.

The Geology of Columbian emerald deposits depicts that the Columbian Andes consist of three sub parallel hill ranges namely, Cordillera Occidental, Cordillera Central and Cordillera Oriental. The western and central ranges consist of granite and well known for gold deposits. The Eastern range consist of sedimentary units of Carbonaceous shale and limestone with limited exposure of igneous and metamorphic units. The major emerald deposits are confined to Eastern (Chivor) and Western (Muzo) margins of Cordillera, Oriental. Muzo is considered as the most important Emerald mines of the world. The Geology of the Muzo district depicts Openheim (1948) that emeralds are confined to lower cretaceous villeta formation, consisting

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of intensely folded and fractured carbonaceous shale and limestone. The highly fractured shale has been invaded by numerous white calcite fracture filling veins in which emeralds occur. Dolomite, quartz, pyrite and parisites are the accessory minerals commonly associated with emerald in these veins.

The sedimentary rock units of Chivor are slightly different lithologically from those described in Muzo, but the geology is basically the same. At Chivor the sedimentary units are almost entirely shale and argillites with minor limestone and sandstone (Rainer, 1929). These sediments are heavily folded and faulted. The prominent section of these units exhibits poorly cemented yellowish shale that overview a thick sequence of grey blue shales and argillites. No emerald whatever is seen in the top capping yellowish shale, but confined mostly to blue-grey argillite around mid section (Johnson, 1961) suggests that the occurrence of emerald of Chivor is structurally controlled, the emerald veins being concentrated in the axes of the tight folds in the argillite. The emeralds occur in veins and occasionally in cavities. The veins run parallel to the bedding plane, which suggests that the gap between the bedding laminae provided the avenues for fissure filling of hydrothermal solutions that crystallised to form vein deposits (Keller, 1981).

3.2.2 GEMSTONES OF METAMORPHIC ORIGIN

The metamorphic process of formation of rocks involves transformation of existing igneous and sedimentary rocks as a result of increasing temperature (300^0-600^{0}C) and pressure in specific geologic conditions. The conditions may be due to the proximity of a magmatic mass of high temperature or may be due to tectonic shearing of a bed rock leading to the increase of temperature and pressure. These changing geological conditions combined with circulating hydrothermal fluid of specific chemical composition makes a realignment of minerals or recrystallisation of the rock mass forming metamorphic rocks. Marble is a metamorphosed rock of limestone, quartzite is of sandstone and granite gneiss is of granite. The characteristic feature of metamorphic rocks are laminated arrangement of minerals in the rock mass resulting from realignment of minerals in the process of formation of metamorphic rocks. A variety of gemstones including Iolite, Jadeite, Lapis Lazuli, Garnet, Spinel and Zoistte (Tanzanite) are formed by metamorphic process. These gemstones are formed and deposited as Regional metamorphic deposit or Contact metamorphic deposit.

Regional metamorphic deposit

The Regional metamorphic deposit again can be due to Low Pressure (High

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temperature) Regional Metamorphism and High Pressure (Low temperature) Regional Metamorphism (Peter C Keller, 1980). Low Pressure (High Temperature) metamorphism occur when two continents collide leading to formation of Mountain ranges as India once collided with rest of Asia generating high temperature and pressure, as a result of which the phenomenon of metamorphism occurred to form gem minerals of ruby, sapphire, emerald, garnet, alexandrite variety of chrysoberyl and Jade, the most significant being the Mogok ruby deposits of North Myanmar When Low Pressure metamorphism takes place over large area / region is called Regional Metamorphism, and in case it takes place locally is called Contract Metamorphsim. Similarly, High Pressure (low temperature) Regional metamorphism commonly occur when ocean floor slides under the edge of the continent. In the process of its downward movement, the ocean floor is subject to great pressure and undergoes metamorphism forming gem minerals like jadeite.

The Regional metamorphism covers the larger mass of rocks in the process of metamorphism including gneiss end schist. When hot magma intrudes into cool country rocks, the rock is heated and saturated by the hydrothermal fluid. Due to increase in temperature and pressure, there is increase in grain size of the minerals in the rock mass and the recrystallisation of minerals in gneiss and schist form gem minerals including iolite, corundum, garnet, chrysoberyl, emerald and tanzanite. A monomineralic limestone, which is composed of calcium carbonate ($CaCo_3$) is metamorphosed to marble. But in case of presence of aluminium in the limestone as impurities, Corundum (Al_20_3) (Ruby, Sapphire), is formed in the process of metamorphism. Like wise, is case of impurities of aluminum in dolomite ($CaMg(Co_3)_2$), Spinel, a Magnesium aluminum Oxide ($MgO.Al_2O_3$) is formed by recrystallisation. A similar Origin can be attributed to blue violet Zoisite (Tanzaite).

Many gem deposits owe their origin to regional metamorphism. With exception from the Columbian Emerald deposits, the rest of the emerald deposits are as a result of regional metamorphism. Low pressure regional metamorphism commonly produce mica schist that may contain gem minerals of various species like garnet, ruby, sapphire and emerald and alexandrite, chrysoberyl as well. The classic example being emerald in biotite schist of Eastern side of Ural Mountain of former USSR.

One of the interesting regional metamorphic gem area is in the East Africa; Gem belt of Kenya and Tanzania. The Precambrian schist of East Africa have yielded ruby, emerald, alexandrite, rhodolite garnet, chrome tourmaline and as well as new species of tanzanite and tsavorite garnet as a result of regional metamorphism.

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The ruby deposits of Jillingdhar in Orissa state and Emerald deposit of Mewar in Rajastan state are as a result of low pressure regional metamorphism.

Contact metamorphic deposit

Similarly when a rock like limestone comes in contact with igneous magma, changes may occur in the contact area. The heat and pressure emanating from invading magma causes recrystallisation of the minerals of the country rock / host rocks by process of contact metamorphism. The common gem minerals formed in this process of contact metamorphism are Ruby, Lapis Lazuli, Beryl, Chrysoberyl. Alexandrite and Emerald variety of Beryl. When a solution from intrusive granitic pegmatite containing beryllium permeate the invaded host rock schist, they react with the rock and form beryl. But in case of trace element of chromium comes from the neighbouring rocks, it forms Emerald. A similar origin can be attributed to Alexandrite variety of Chrysoberyl as a product of contact metamorphism. Mogok ruby deposit in upper Myanmar is the most classical gem deposit of the world, which has attracted the gemologists for centuries. It is a typical example of contact metamorphism although some geologists have different view of its Low pressure regional metamorphic Origin. The Geology of the Mogok area depicts occurrence of high grade metamorphic schists and gneisses and granite intrusives including gem bearing pegmatites, Peridot bearing ultramafic rocks and most significantly ruby and spinel bearing metamorphic marble. The marble has been intruded by granitic rocks and the effects of contact metamorphism have been evident from the presence of feldspar and diopsides in coarse grained portion in contact with the granitic rocks. When the granific intrusion comes in contact with the limestone containing aluminum rich impunities, it is recrystallised into course grained calcite crystals to form crystalline limestone or marble and aluminum into corundum (Al_2O_3). If the limestone is magnesium rich dolomite, Spinel ($MgAl_2O_4$) is formed. This makes the theory of origin of ruby and spinel of Mogok stone Tract of Myanmar formed as a result of contact metamorphism.

3.2.3 GEMSTONES OF SEDIMENTARY ORIGIN

The Sedimentary process of formation of rocks involves mechanical disintegration or chemical alteration of igneous, metamorphic and sedimentary rocks at the surface of the crust by weathering process. This weathering process may be by mechanical weathering or by chemical weathering depending upon its mode.

The mechanical weathering process of a country rock could retain the same

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mineral composition of the original rocks, from where they are disintegrated, transported and deposited as sedimentary rocks. The weathering agents involved in case of mechanical weathering includes wind, rain, snow and ice. On the contrary there may be complete alteration of the mineral composition in case of chemical weathering process of formation of sedimentary rocks. In this process minerals go into solution and precipitated by chemical reaction, evaporation and organisms, where water is the key agent. Beds of Rock phosphates, Gypsum and Rock salts are examples of sedimentary rocks formed by chemical weathering.

The most of the gemstones are deposited as mechanically sedimentary rocks as colluvial and alluvial deposit or residual concentration in the in situ weathered rock as eluvial deposit. The minerals having high hardness and toughness to withstand mechanical weathering, chemically inert to resist attack by natural acid or base and relative high density to facilitate concentration, could accumulate as eluvial deposits.

The top of the diamondiferous pipe rocks Kimberlite remain as cone shaped mountain, which over 100 million years have been eroded leaving some remnant of diamond bearing rocks as eluvial deposit as clue for the Geologist for exploration and mining of diamond deposits. The eroded materials have been carried away by weathering agents into low lying hillocks (South African Kopjes) as colluvial deposit. The eroded diamondiferous materials are further carried away by streams / rivers bed and marine terraces as alluvial or placer deposit.

The ability of the stream to carry these heavy mineral grains depend mostly on the velocity of water. When the velocity of water is quite fast, the heavier placer gems are obviously swept away and sometimes dissipated. On contrast, when the velocity of water is too low, the associated minerals could not be removed. Therefore, the optimal conditions for deposition and accumulation of placer gems is slacking of the velocity of water of the stream. The velocity of the stream flow could be reduced by change of gradient of the water course, meandering of the water course or natural obstruction of massive rocks in the river bed, which permits heavier minerals to drop and accumulate leading to enrichment of rich and high quality placer gem deposits.

The most prolific gems deposits of the world occur as alluvial or placer deposits having rich concentration of diamond and coloured stone, which includes diamond, zircon, Ruby, Sapphire, Chrysoberyl (alexandrite), beryl, aquamarine, moonstone, garnet, jade, tourmaline, spinel, topaz and tanzanite of high quality all over the world as secondary mineral deposit.

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The most significant and prolific placer deposits of the world are vested in Illam and Ratapuna of Sri Lanka, Mogok valley of Myanmar, Minas Gerais of Brazil, gem gravel of Thailand and gem gravel of Malagasy Republic.

The diamondiferous beach sands occur in either side of the mouth of the Orange river in South Africa and Namibian coast of South Atlantic by weathering, transportation and deposition of Kimberlites and form the richest placer diamond deposits of the world (Webster, 1975). The origin of diamond occurs in the gravels and conglomerates under considerable thickness of sand along the Atlantic coast, appears to have been eroded, transported and deposited in coast line from the Kimberlitic pipe rocks of Lesotho, Republic of South Africa and Botswana located in the central part of the Southern African subcontinent. Huge quantities of eroded debris were transported by the Vaal river, the Orange river and the Buffels down to the sea millions of year ago. The heavier minerals and diamonds initially deposited in the coast line have been distributed up and down the coast by wind wave action of the sea. The impact of the sea wave have caused the poor quality diamond to disintegrate and wash away leaving the better quality diamonds lodged into the fissures and crevices of the hard rock of precambrian schists formed 800-1000 million years ago forming richest marine placer deposits of the world containing prolific gem quality diamond. Around Orangemund and Namaqualand in Namibian and South African coast of South Atlantic. The diamonds are generally associated with gravels, pebbles and boulders and occasionally cemented into conglomerates in terraces that formed ancient marine beaches. They are now overlain by considerable thickness of windblown sand.

The world's most famous diamonds come from the alluvial diamond deposits of India in the Eastern Sector of Deccan Plateau including Golconda mines in state of Maharastra, Panna mines in Madhya Pradesh and gem gravel of the river Mahanadi in the state of Orissa. Brazil has also important placer diamond deposits in Bahia and Dinmantina of Minas Gerais district. The alluvial diamond deposits also occur in Yuan river in Hunan of China. Similarly, in Thailand, volcanogenic sapphires have been eroded, transported and deposited in Gulf of Siam in marine terraces by river which is being mined as sea bed deposit.

Out of all these, the most prolific placer gems deposits are found in the tropical island of Sri Lanka, known as Island of Gems. The Gem gravel of Sri Lanka, Illam, located at Elahera and Ratnapura gem field contain the entire spectrum of gem varieties barring diamond and emerald. The rich gem gravel yields chrysoberyl cat's

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Eye, Alexandrite cats Eye, Star Sapphire, Ruby, Moonstone, garnet, spinel, Zircon, Peridot, tourmaline, topaz etc. and other rare gem species for many centuries derived from Precambrian metamorphic sequences covering 90% of the Island (Keller).

The country is geologically covered predominantly by regionally metamorphosed precambrian rocks and intrusive granites, barring a narrow band of Miocene limestone and calcareous sandstone in the North-Western coast, which is a geological continuation of the Archean granulite complex of Southern India, from which the Island has been possibly delinked.

Cooray (1967) has classified the Precambrian, rocks of Sri Lanka into three major units,

(i) High Land Series Containing garnetiferous gneisses with charnockite, quartzites, marbles and granites.

(ii) Vijayan series consisting of hornblende biotite gneiss and associated granite.

(iii) South western groups consisting of cordierite, hypersthene and sillimanite gneisses

The placer deposit of Sri Lanka being the richest source of wide species of gemstones has attracted and fascinated the scholars of gemstone for extensive researches on their origin leading to divergent view. Adams (1929) was of the view that the Gems minerals have been derived from the underlying crystalline of Highland series. Katz (1972) propounded that the destructive paragenesis of the cordierite gneisses of the South Western group could be the possible source of origin of the gem minerals. Wadia and Fernando (1945) however proposed a pegmatitic origin by which the typical pegmatite minerals such as beryl, moonstone, tourmaline and topaz have been derived. This theory however could not gain ground from geochemical point of view and for the simple reason that such vast deposits of gemstone could not have come from relatively limited pegmatite deposits of the country. Silva (1976) on the other hand suggested that the garnetiferous gneisses of the High land series are the most likely source, because of their close proximity to the overlying gravel, the underlying rocks of Elahara and Ratnapura being of rocks of High land series and the geochemical considerations.

Dahanayake, Liyanage and Ranasinghe (1980) however have made a compromise theory postulating the fact that Ruby, Blue sapphire and spinels have been derived from garnetiferous gneisses, where as topaz, beryl, chrsoberyl cat's eye, tourmaline have come from localized pegmatites.

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3.2.4 GEMSTONES FORMED FROM SUPERGENE ENRICHMENT

Gemstones also owe their origin to secondary mineralization or supergene enrichment of dissolved minerals in specific geologic environment. Surface water plays an important role in formation of gem minerals through chemical reaction, evaporation on occasionally cooling of hot water. Rainwater combines with atmospheric carbon dioxide to form relatively weak natural acid called carbonic acid. When this solution penetrates into earth and encounter pyrites (Fes), a much stronger sulphuric acid formed that could dissolves minerals, transport the chemical elements and permeate into adjoining rocks to form new minerals. For example, Malachite, $Cu_2CO_3(OH)_2$ is formed when copper bearing solution reacts with limestone (CaCo3).

In arid region, the conditions are quite favourable for formation of opal deposits by evaporation, During isolated showers, the rain water percolates down to permeable rocks rich in silica (SiO2), dissolves silica from these rocks and carries down the water table to get concentrated. During the dry season, some of the water get evaporated and as a result the remaining solution becomes rich in colloidal silica from which opal or solid silica containing water is deposited to form opal deposit. In this process, gemstones that may be formed are Turquoise, malachite, opal, amethyst and rhodochrosite when copper bearing acid solutions percolates into porous volcanic rocks and reacts with mineral containing aluminum and phosphor.

The most significant opal deposits of the world are vested in South Australia where hidrous silica has been precipitated in silicious sandstone as Supergene deposit. In Neveda, United states of America, Turquiose deposits have been formed by supergene enrichment of pre existing minerals in alumina rich volcanic rocks.

The world's finest turquoise deposits have been formed and occur at Nishapur district of Iran (Gubelin, 1966) and Hubai Province of China.

The world's finest gem quality malachite deposits are in Ural mountains of USSR particularly from Gumeschevsk and Mednoroudiansk mine as primary gems deposit of sedimentary Origin. Out of these gemstone deposits, Opal happens to be the finest gem deposits of Australia. The best knows deposits are located in the arid region of western and central Australia around Andamooca, Coober. Pedy and Mintabie in South Australia and Lighting Ridges and White Cliffs in New South Wales. The above significant opal deposits except Mintabie are confined to Cretaceous marine sediments. During the cretaceous and early tertiary period, the region experienced rapid climate changes of temperature, the shallow marine area becoming desert

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habitat. About 15 to 20 million years ago, regional peneplanation occurred resulting in chemical weathering (David, 1950), which was instrumental for formation of opal deposits. The opal deposits occur as irregular nodules and thin veins in horizontal and vertical joints and found to occur 6-10M below the surface.

3.3 GENETIC CLASSIFICATION OF GEMSTONE DEPOSITS

The genetic classification of ore deposits have been tried by Geoscientists from AGRICOLA'S (1490-1555) time. Geoscientists like Nigli (1929) and more recently Charles Mayer (1981) and Lindgren (1985) suggested classification of ore deposits only after revelation of more facts on origin of ore deposits by researchers in the later part of twentieth century. But no attempt has been made as yet to classify gemstone deposits based on their origin by scholars of gemmology, probably for the fact that very limited works have been done on the origin of gemstone deposits. In view of the influx of sizable synthetic gems and their simulants to the world market, the Gemologists are more concerned in identification, aesthetics, nomenclature and gemmological parameters to distinguish natural gems from their synthetics and stimulants than in fundamental aspect of genesis of gemstone. The Petrologists and Minerologists on the other hand have shown interests in genesis, formation and occurrence of rocks and minerals than in origin of gemstone.

Lewis (1887) was the first Geoscientist who named kimberlite as diamond bearing ultramalic breccia in volcanic vent in Kimberley district of South Africa for the fact that diamond aroused interest to unravel their origin. In recent years the origin and development of kimberlite and diamond geology have been reflected in the review papers by Dawson (1968), Kennedy and Nordie (1968) and Mayer (1976), which gives a comprehensive history of the origin of diamond and the associated kimberlite, though lacks in reflecting on gem quality diamond.

In the field of coloured gemstone, Gubelin (1941-1971). Sinkanakas (1968 - 1981), Kennedy (1950), Schlossmacher (1954), made major contribution on origin of gemstone, which made comprehensive introduction to the science of Geology. Darrah (1966) and Dahanayake (1980) threw light on the sedimentary origin of gem deposits, which didn't attract the attention of Geoscientists earlier years. But more significantly P.C. Keller (1981, 1982, 1986, 1990) have outlined the most important geological events, which has led to the formation of different types of gemstone deposits in the world, which is no doubt a remarkable contribution on origin of gemstone deposits. With the recognition of the role of magmatic, sedimentary and metamorphic activities

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in formation of gem minerals and better understanding of geochemistry, lithogenesis and litho tectonics those have been responsible for formation of gems minerals, it may be worth while to make an attempt to classify gemstone deposits, which may be of interest to students of gemology.

Gemstone deposits all over the world depending upon their genesis or mode of origin could be classified into two categories;

(i) Primary Gems Deposits

(ii) Secondary Gems Deposits

3.3.1 PRIMARY GEMS DEPOSITS

The primary gems deposits are those which are formed in the process of formation of igneous and metamorphic rocks in the Earth's Crust. They are formed by way of;

(i) Crystallization of molten magma in the process of formation of igneous rocks.

(ii) Crystallization from pegmatitic fluid or aqueous solutions associated with molten magma in process of formation of Granite - Pegmatite rocks.

(iii) Crystallization from upward moving hydrothermal solutions emanating from crystallizing magma in process of formation of igneous rocks.

(iv) Metamorphic re-crystallization in process of formation of metallic rocks.

3.3.2 SECONDARY GEMS DEPOSIT

The secondary gem deposits are those, the genesis of which involves;

(i) Physical disintegration or chemical alternation by weathering process of country rocks from where they were originated as primary deposits.

(ii) Mineralization, which comes as a near surface deposit in process of secondary on supergene enrichment of primary gems deposits by percolating ground water in cracks and crevices.

The primary gem deposits may be of igneous, sedimentary ad metamorphic origins and can be subdivided depending upon its mode of Origin. The Igneous as volcanic, magmatic, hydrothermal, pegmatitic deposits, regional metamorphic and contact metamorphic deposits. Similarly the secondary deposits are basically of sedimentary origin and can be subdivided depending upon its mode of occurrence

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such as Eluvial, Colluvial and alluvial deposits and deposits of supergene enrichment. A genetic classification of the gem deposits have been attempted depending upon the concept discussed.

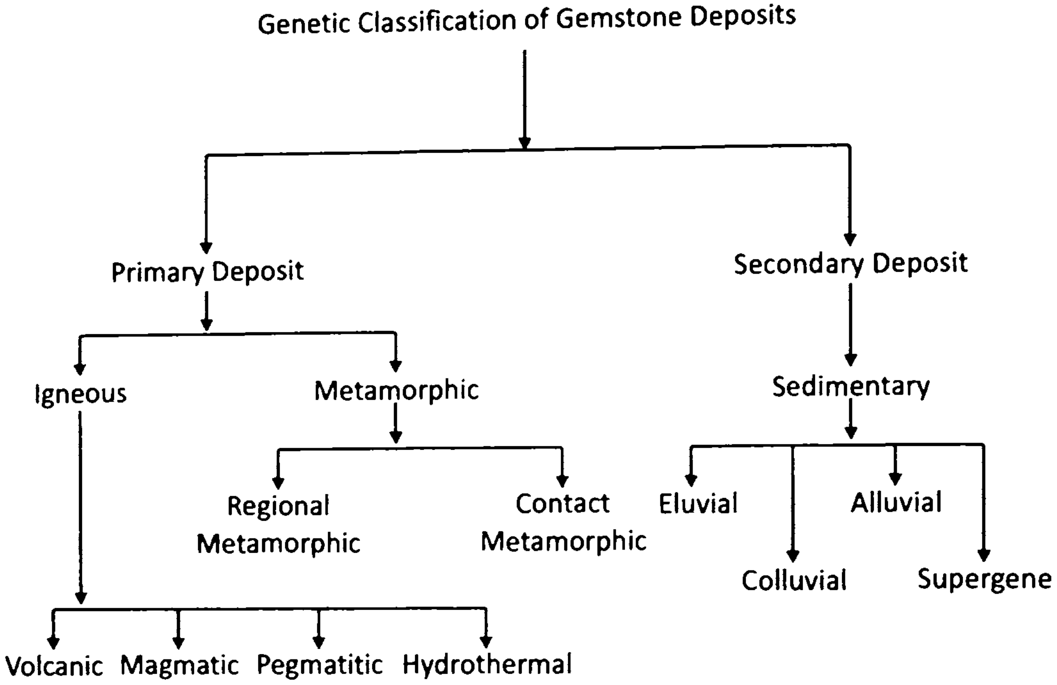

TABLE : 3.2 GENETIC CLASSIFICATION OF GEMSTONE DEPOSITS

Deposit category	Origin	Type of deposit	Gemstone	Type occurrence
PRIMARY DEPOSIT	IGNEOUS	Volcanic	Peridot	Peridot Mesa, San Carlos, Arizona, USA
			Amethyst / Chalcedony	Deccan Traps of India
			Moonstone	Ambalangoda in Southern province and Kandy in Central province of Srilanka, Coimbatore in Tamilnadu state of India
		Magmatic Deposit	Peridot	Zabargad Island, Egypt

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PRIMARY DEPOSIT	IGNEOUS		Ruby	BoRai and Bo Waen of Tract Province, Thailand
			Sapphire	Khao Ploi Waen and Bang Kha Cha of Chanthaburi province, Thailand, Yugo Gulch Mine, Montana, USA
			Quartz (Aventurine)	Green Aventurine in Deccan Trap of India
			Zircon	Alkali basalts of Pailin of Kampuchea, Anakie, Queensland, Australia
			Diamond	Kimberlite Pipes of South Africa and Lamphroite pipe in Argyle, Australia.
		Pegmatitic Deposit	Aquamarine	Pegmatities of Minas Gerais, Brazil
			Tourmaline	
			Spodumene (Kunzite)	
			Topaz & Morganite	
			Chrysoberyl (Alexandrite)	Ural Mountains of USSR
			Feldspar (Moonstone)	Malagasy Republic
			Quartz (Rose Quartz)	Ural Mountain of USSR
		Hydrothermal deposit	Emerald	Muzo and Chivor district of Columbia, USA
			Amethyst	Mursika district in Ural Mountain, USSR
			Topaz	Ouro Preto, Minas Gerais of Brazil

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PRIMARY DEPOSIT	METAMORPHIC	Regional Metamorphic Deposit	Emerald	Saila Terezinha Goias and Nova Era of Minas Gerais, Brazil, Ural Mountain of Former USSR
			Spinel	Pamir Mountains of USSR
			Tanzanite	Precambrian Schist of Tanzania
			Iolite	Cordierite Schist of Orissa, India
			Ruby	Precambrian Schist of Kenya and Tanzania
			Tsavorite Garnet	Tsava National Park, Kenya
			Rhodolite Garnet	East African Gem belt of Kenya
			Jadeite	Tawmaw and Hpakon deposit of North Myanmar
		Contact Metamorphic Deposit	Ruby	Mogok Stone Tract of Myanmar
			Lapis Lazuli	Crystalline Limestone of Badakshan of Afganistan
SECONDARY DEPOSITS	SEDIMENTARY	Eluvial Deposits	Peridot	Peridot Mesa, San Corlos, Arizona, Navano Indian country of New Mexico
		Colluvial Deposits	Diamond	Diamond deposits of low lying hillock of South Africa (Kopjes)
		Alluvial Deposits	Sapphire	Sapphire deposit of Gulf of Siam, Thailand
			Diamond	Marine terrace deposit in Colluvial Orajemund and Namgunaland in Namibian and South Africa coast of South Atlantic

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AQUAMARINE

Aquamarine is the birthstone for March. Historically, significant amounts of fine gem aquamarine have been limited almost exclusively to the pegmatites of Minas Gerais, Brazil. Recently, however, the Nuristan region of Afghanistan has produced some fine aquamarine, as evidenced by this 75.8-carat faceted stone and almost 5-centimeter-high cluster of gem-quality crystals.

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SECONDARY DEPOSITS	SEDIMENTARY		Zircon, Garnet, Tourmaline, Alexandrite, Aquamarine, Sapphire, Diamond, Moonstone, Ruby	Gem gravel of Srilanka, Gem gravel of Myanmar, Gem gravel of Thailand, Gem gravel of Malagasy Republic and Gem gravel of Minas Gerais of Brazil
		Supergene Deposits	Turquoise	Nishapur in Kharasan, Iran and Hubei province, China.
			Opal	Coober Peedy and Mintabie of South Australia
			Malachite	Gumeschevsk and Mednoroudiansk mine of Ural Mountain of USSR

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CHAPTER IV

WORLD OCCURRNCES OF GEMSTONES

4.1 MAJOR OCCURRENCES OF GEMSTONES

The occurrence of major gemstone deposits of the World, their geological milieu and their geographical distribution pattern depicts an interesting profile. The scholars of gemstones have always described gemstones as prerogative of East and termed them as Oriental. It appears to be true. If you analyse the pattern of occurrence of gemstone deposits of the world, you may however find that the world's major gemstones are concentrated in a tiny island of Indian ocean, Sri Lanka (25,000 sq. mile), which contain rich deposits of Ruby, Sapphire, Cat's Eye and Alexandrite variety of Chrysoberyl, Tourmaline, topaz, Zircon, Moonstone, Spinel, Garnet and Peridot in most prolific placer deposit of the world except Diamond and Emerald, which occur in India, north of the Island.

Moving far North of Sri Lanka, we find a vast stretch of land in Central Asia in Confederation of Independent states (Former USSR), where excellent gemstone deposits of Emerald, Alexandrite, Tourmaline, Aquamarine, Demantoid (garnet) and Amethyst occur as a product of regional metamorphic activity, which together with the deposits of Sri Lanka cover the entire varieties of coloured gems in North- South alignment in respect of Srilanka -USSR in the continent of Asia.

Moving North East of Sri Lanka, though not far, major reserves of Ruby and Sapphire of the world are vested in Myanmar and Thailand. The Mogok and Nam Hsu Valley of Upper Myanmar are classic deposits of Ruby and Sapphire of the world being associated with high-grade metamorphic schist and gneiss predominately Mogok gneiss. The Bo Rai and Bang Kha Cha district of Chantaburi - Tract province of Thailand and Pailin area of Kampuchea contribute major bulk of ruby and sapphire of the world being associated with Chanthaburi-Tract basalts and their weathered derivatives. Many of the world's finest gem rubies and sapphire also come from the gem gravels of Myanmar and Thailand too.

In the South-East of Sri Lanka, gem deposits of Sapphire and Zircon of metamorphic origin occur in Anakie, Central Queensland and Inveral, New South Wales of Australia. The famous precious opal deposits of secondary origin occur in Andamooca, Coober Pedy, Mintabie in South Australia and and Lighting Ridge and White Cliffs in New Southwales, which are being mined at present.

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In West of Sri Lanka, in the continent of Africa, blue Sapphire, Emerald, Aquamarine, Garnet and Tourmaline deposits occur in the gem gravel of Malagasy. Besides, substantial deposits of garnet and emerald occur in Zimbabwe, Zambia and Namibia and Tanzanite in Tanzania in precambrian metamorphic schists and gneisses of African shield.

In far South West of Sri Lanka comes the continent of South America. Chivor and Muzo, the principal emerald bearing regions of Columbia, produce the finest Emerald of hydrothermal origin and gem quality Topaz deposits of pegmatitic origin in vein of Duro Preto in Minas Gerais of Brazil. Brazil also produces Amethyst, Tourmaline, Topaz, Aquamarine, Spodumene (Kunzite) and Emerald from the gem pegmatites of Minas Gerais in South American Continent in East-West alignment of Sri Lanka. Similarly in the west of USSR, continent of North America happens to be important source of Tourmaline, Sapphire, Peridot, Opal, Spodumene and Garnet of significance falling in East-West alignment only.

In the field of diamond deposits, India continued as the principal source of diamond for centuries in alluvial deposits until discovery of alluvial diamond deposits in Brazil in 1725. The state of Minas Gerais dominated the world production of diamond for 150 years after India and still remain the potential source of diamond from the alluvial deposits which also happens to be in the East - West alignment of Indian peninsula in Asia and Brazil in South American Countinent.

The occurrence of diamond deposits in diamondiferous Kimberlite and Lamphroite pipes throughout the world appears to have been distributed in relation to East - West alignment only. There are significant clusters of diamond deposits in Siberian region of USSR in Asia, supposed to be the second largest producer of diamond next to South Africa and potential Kimberlite pipes in North America which includes, Lac de Gras and Cotaco Cotaco Mines of Canada said to be the fourth largest producing diamond in the world at present. There are widely distributed diamondiferous Kimberlite pipes in African shield in west of India and Lamphroitic pipes in Australia, South East of India occurs in East – West alignment in addition to the alluvial deposits, which also owes its origin from primary diamond deposits.

In the South West of India, the Republic of South Africa from its famous Kimberley Mines and Premier Mines and together with the production from Botswana, Lesotho and Namibia produces 50% of world's total production of gem diamond. In the South East of India, the Argyle and Ellendale diamond deposits of

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Lamphroitic pipes occur in Australia being one of the most modern mechanized diamond mines of the world. In the due West of India, Zaire, Siera, Leone and Angola, in the continent of Africa produces 60% of world's industrial diamond.

It is believed that diamond has been formed in geologic environment of high temperature and pressure in deep seated mantle of the earth at a depth of 200 km from the surface of the Earth's crust in Kimberlite and Lamphroite pipe rocks 150 million years before. Asia, Australia, Africa and South America and North America, where primary diamond deposits were formed in deep seated plutonic environment are said to have been together millions of years before and believed to have been separated by drifting of continental plates by the geological process of mechanism of plate tectonic, which not only explains the theory of plate tectonics, but also justifies the dissipated occurrence of diamondiferous Kimberlite-Lamphroite throughout the world.

The occurrence of major gemstone deposits of the world and the Geological milieu they usually occur are given in Table 4.1.

TABLE 4.1 GEOLOGICAL MILIEUS AND MAJOR WORLD OCCURRENCE OF GEMSTONE

Sl. No	Gemstone	Geological Milieu	Occurrence
1.	Aquamarine	Contact of beryl bearing pegmatite with granitic rocks and Gem gravels	Minas Gerais of Brazil, Urals, Transbaikalia and Siberia of USSR, Malagasy Republic, Zambia, Namibia, Nigeria of South Africa, Pegmatities of India and Gem gravel of Sri Lanka
2.	Emerald	Contact of beryl bearing pegmatite with ultramafic rocks, hydrothermal deposits in limestone, and biotitic schist.	Muzo and Chivor district of Columbia, Santa Terezinha de Goias and Nova Era regions of Brazil, Swat Valley of Pakistan, Ural Mountain of USSR, Zambia, Zimbabwe and Tanzania of South Africa, India
3.	Ruby Star Ruby	Granite gneiss, crystalline limestone, mica schist, nepheline syenite and gem gravel	Mogok of Myanmar, Thailand, Ratnapura and Rakwana of Sri Lanka, Kenya and Tanzania of South Africa, Kalahandi of India, Nam, HSO valley of Afganistan

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4.	Sapphire Star Sapphire	Granite gneiss, dyke of lamprophyre, crystalline limestone, mica schist, nepheline syenite, contact of Marble and pegmatite and gem gravel	Myanmar, Kanchanburi area of West Bankok in Thailand, Yugo, Gulch deposit of Montana, USA, Sri Lanka, Zaskar district of Kashmir, India, Central Anaki, Queensland and Inverel of New South Wales of Australia, East Africa, Nigeria
5.	Diamond	Kimberlite Pipe, Lamphroite Pipe, and Gem gravel	Alluvial deposits of India, Kimberley and premier deposits of South Africa, Botswana, Lesotho and Namibia, Alluvial deposits of Minas Gerais and Bahia of Brazil, Mir Pipe of USSR & Argyle pipe of Western Australia, Lac de Gras and Cotaco Cotaco of Canada
6.	Chrysoberyl, Chrysoberyl Cat's Eye	Granite gneiss, Pegmatite and Mica schist and Gem gravel	Takovaya of Ural Mountain of USSR, Gem gravel of Sri Lanka, Hematita in Minas Gerais of Brazil, Myanmar, Zimbabwe, Zambia, Malagasy Republic.
7.	Alexandrite, Alexandrite Cat's Eye	Granite gneiss, Pegmatite and Mica schist and gem gravel	Lanka, Myanmar, Former USSR, Zambia, Hematita in Minas Gerais of Brazil
8.	Moonstone	Granite Pegmatite and Gem gravel	Gem gravel of Sri Lanka, Myanmar, Malagasy Republic, India, Tanzania, USA
9.	Amazonstone	Granite Pegmatite and Gem gravel	Ural Mountain of USSR, Minas Gerais of Brazil, Pikes Peak of Colorado, Amelia Court House, Virginia, USA
10.	Pyrope / Rhodolite	High grade pelific schist at the contact of granite gneiss and amphibolite	Czechoslovakia, Sri Lanka, Myanmar, Kimberley, South Africa, Tanzania, USA, Former USSR, India
11.	Almandine	Gem gravel and metamorphic rock	Austria, China, Sri Lanka, India, Myanmar, Brazil, USA, Tanzania, Malagasy Republic, Czechoslovakia

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12.	Spessartite	Gem gravel and low grade metamorphic rocks	Sri Lanka, Myanmar, Malagasy Republic, Brazil, Amelia, Court House, Virginia, Sandiago County, California, USA, Mexico.
13.	Grassularite / Hessonite / Tsavorite	Gem Gravel	Tsavo National Park in Kenya, Tanzania, South Africa, Sri Lanka, Quebec, Canada, Brazil, New Zealand (Demantoid)
14.	Andradite	Metamorphosed limestone and rarely in intrusive and extrusive igneous rocks	Alluvial deposits in Ural Mountain, USSR, Ala Valley, Piemant, Italy, Zermatt, Switzerland, USA, Noway, Germany
15.	Uvarovite	Metamorphosed limestone with intrusion of ultramafic rocks	Ural Mountain, USSR, Outokumpu, Finland, Poland, USA, Canada
16.	Iolite	Pelitic schist, Cordierite gneiss and Gem gravel	Myanmar, Sri Lanka, Malagasy Republic, Tanzania, India, Brazil
17.	Jade / Jadeite / Nephrite	Jadeite occurs in serpentine and Nephrite in crystalline dolomitic limestone	Tawman Hpakon of Myanmar, Khotan in Turkeystan, Lake Baikal, USSR, New zealand, Jade Mountain, Alaska, USA
18.	Lapis Lazuli	Crystalline Limestone	Badakstam, Afganistan, Lake Baikal, Siberia, USSR, Andes of Ovalle, Chile, Baffin Island, Canada, San Bernadino, California, USA
19.	Opal	Near surface deposit by circular ground water or in low temperature hydrothermal solution and marine sediments	India, Czechoslovakia, Queensland, New South Wales of Australia, Queretaro, Mexico, Piaui State, Brazil, USA
20.	Peridot (Olivine)	Olivine crystals grown in open fissure and cavities	Zeberget of Red Sea Island, Egypt, Australia, Brazil, Tanzania, Kenya, Norway, Sri Lanka, San Carlo Apache, Indian Reservation, Arizona, USA, China, Mexico

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21.	Amethyst	Geodes that formed in cavities of lava flow in hydrothermal phase	Uruguay, USA, Brazil, Zambia, Sri Lanka, India, Madagasy Republic, Ural Mountain of USSR, Australia
22.	Rose Quartz	Pegmatite	Brazil, USA, Madagasy Republic, India, Nambia
23.	Citrine Quartz	Pegmatite	Brazil, Uruguay
24.	Aventurine	Fuchsite Mica Schist containing chromite bearing muscovite	India
25.	Carnelian	Metamorphic rock types	India, Brazil, Uruguay, USA
26.	Agate	Metamorphosed rocks	Idar-oberstein, Germany, Uruguay, Brazil
27.	Spinel	Metamorphic rocks, contact metamorphic mineral in limestone, and Gem gravels	Gem gravels of Sri Lanka, Myanmar, Thailand, Umla River of Tanzania, Pamir Mountain of USSR
28.	Spodumene (Kunzite)	Pegmatite associated with lithium bearing minerals	Afganistan, Myanmar, Minas Gerai, Brazil, Stoney Point, North Carolina, Pala, California of USA (Pink Spodumene / Kunzite) Malagasy Republic Afghanistan
29.	Topaz	Topaz is formed by fluorine bearing vapours given off by the last stage of solidification of igneous rocks, occur in pegmatitie and gem gravel	Ouro Preto, Brazil, Nerchinsk of Siberia, Mursinsk , Ural Mountain, USSR, Mardan, Pakistan, Gem Gravel of Sri Lanka, Pegmatite of Mogok, Myanmar
30.	Tourmaline	Granite pegmatite associated with spodumene, topaz, quartz, beryl and metamorphosed limestone and gem gravel	Malagasy Republic, Namibia, Mozambique, Nuristan, Afganistan, Ural Mountain of USSR, Gem gravel of Minas Gerais of Brazil, Myanmar and Sri Lanka, USA

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31.	Turquoise	Small veins of less decomposed volcanic rocks	Nishapur in Khoram of Iran, Sinai Peninsula, Israel, Uzbeck Republic, USSR, China (Tibet), USA
32.	Zircon	Igneous rock and gem gravels	Laos, Cambodia Thailand, Upper Myanmar, Gem gravel of Sri Lanka, New South Wales, Australia, France
33.	Zoisite (Tanzanite)	Metamorphosed limestone in the contact of intermediate Precambrian schist and gneiss in Tanzania	Tanzania, Norway, Australia, South Africa (Thulite)

4.2 MAJOR OCCURRENCES OF ORGANIC GEMS

Apart from occurrence of inorganic gemstones of mineral origin, there are many fashionable organic materials categorized as gems, which include amber, coral, Ivory, Pearl, Jet, Shell and Tortoise shell formed in diverse biological milieu, all over the world. These gem materials no doubt have been valued and used as most adornable gems since Neolithic period. The major occurrence of those gems and their mode of origin has been outlined in Table 4.2.

Table 4.2 OCCURRENCES OF ORGANIC GEMS

Sl. No.	Gems	Biological milieu	Occurrence
1.	Amber	A honey yellow fossilized form of resin consisting of hydrocarbons and succinic acid extruded from the trunks of various trees including coniferous trees in Miocene to Paleocene period	Southern coast of Baltic Sea, Sea Amber in Black Sea, Coast line of Sicily and Shore of Baltic Sea and Pit amber from Kaliningrad of former USSR, Sicily, Romania and Myanmar
2.	Coral	Consist of Calcium Carbonate, Magnesium Carbonate and Proteinaceous substance and comes from Calcareous skeleton of colonies of marine organisms, living in shallow tropical water of Mediterranean Sea	White, Pink and Red Corals in Western Mediterranean Sea, Coastline of Australia, Japanee and Malaysian Seas

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3.	Ivory	Basically dentine Ivory from tusks of elephants and also from the tusk of Walrus and Hippopotamus, tooth of Narwhal and teeth of Sperm whale and also from the tusks of fossilized Mammoth	Indian and African elephants, Mammoth ivory from Ural and Siberia of former USSR
4.	Natural Pearl	Natural Pearl is formed inside a Pearl oyster by way of penetration of parasitic larvae in creatures shell and causing an irritation.	Persian Gulf, Sri Lanka, Red Sea and Philippines. The black pearls in pacific coast of Mexico and Gulf of California. Pink Pearls in Florida and West Indies.
5.	Cultured Pearl	Cultured Pearl is cultivated by way of artificially injecting Mother of Pearl bead and a Cube into a Pearl oyster and allowing it to grow in waters	Japan, North West coast of Australia and coast water of India, Fresh water Pearls are harvested in the rivers of UK, USA, Former USSR & China
6.	Jet	Carboniferous fossilized and containing traces of mineral elements of aluminium, silicon, sulphur and mineral oil	Yorkshire Coast of UK, Spain, France, Germany, Former USSR and USA
7.	Shell	Pearl mollusk or Oyster shell having same luster as that of encapsuled Pearl	Haliotis shell in North America, Australia, Japanese, Korean and New Zealand Waters, Cameo Shell in coastline of Malagasy Republic, Helmet Cell in West Indian Waters
8.	Tortoise shell	Salvaged from outer shell of Hawk Shill Sea Turtle	Tropical and Subtropical Seas of Malayasia, West Indies and Brazil

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CHAPTER V

GEMSTONES OF INDIA

5.1 INTRODUCTION

India has rich resources of gemstones from Diamond to Pearl since ancient time. There was organized mining for production of Diamond around Golconda, Kollur, Ellore, Nandial in Krishna river basin in Andhra Pradesh, Cuddapah in Tamilnadu, Panna in Madhya Pradesh and Sambalpur in from bedded and placer deposits which were meeting the world supply of diamond. So also the case of coloured gemstones like Emerald, Ruby, Sapphire, Crysoberyl cat's Eye, Alexandrite, Garnet, Tourmaline, Zircon, Iolite, Moonstone, Amethysts etc., which were mined in the country in different gem rich states since time immemorial. These resources are to be rediscovered and there is a need for exploration and development of these potential gem deposits for organized mining to meet the increasing demand in the country.

India is considered as one of the leading gemstone fashioning country in the world fashioning 80% of world production of faceted Diamonds. Similarly, for coloured gems, out of the five leading fashioning centres of the world, Jaipur in India is one of them, producing largest quality of faceted Emeralds in the world. India is also in the forefront of trading of gemstone basically Diamond until Eighteenth Century both to the Western Countries and far East Countries from the Port of Nilewar, Goa and Barygaza in the West coast and Kalinga Coast in the East Coast.

The gemstone deposits of India are mostly confined to geological formations of magmatic, metamorphic and sedimentary rocks occurring in the state of, Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Tamilnadu, Karnataka, Rajastan, Kerala and Kashmir. The country is bestowed with remarkable gemstones such as Emerald, Aquamarine, Chalcedony, Ruby, Star Ruby, Sapphire, Star Sapphire, Chrysoberyl, Chrysoberyl Cat's Eye, Alexandrite, Alexandrite Cat's Eye, Diamond, Moonstone, Amazon Stone, Alexandrite, Garnet, Pyrope, Rhodolite Garnet, Uvarovite, Hessonite, Iolite, Agate, Amethyst, Rose Quartz, Aventurine, Sillimanite, Sillimanite Cat's Eye, Topaz, Tourmaline, Zircon, Coral and Pearls having world class deposits of Diamond, Ruby, Sapphire, Iolite, Chrysoberyl Cat's Eye, Amethyst and Aventurine.

The Odisha state has a rich concentration of gemstone including diamond. The state has taken lead since 1982 in exploration, development and exploratory mining

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of Aquamarine, Garnet, Chrysoberyl Cat's Eye, Ruby, Iolite, Sillimanite Cat's Eye and Diamond and development of fashioning of coloured gemstone in scientific manner which has been discussed in subsequent chapters in details. Although India possesses prolific Diamond diatremes, lacks in application of cost intensive and modern technique of exploration and development of Diamond deposits for which Diamond deposits are unraveled for production. The state has taken the appropriate steps for exploration, development and mining of diamond deposits.

In the filed of fashioning of gemstone, India lacks in the quality of diamond fashioning and shaping of coloured stones to compete in the international market for which technology upgradation of the fashion industry is essential. For meeting the shortfall of the gemstone roughs, proper marketing techniques are to be adopted to procure gemstone roughs in gem rich states.

This book apart from emphasizing on process of Geology, exploration, mining and fashioning of gemstones in the country, focused on adoption of a National gemstone policy taking experience into account for lopsided development of gem industry in the country. It is suggested that other gem bearing state should take recourse to the similar efforts and experience of Orissa for resource identification and development of gemstone deposits in India.

Today new challenges are to be met by the Gemmologist in determining

(i) Synthetic gem minerals

(ii) Colour enhancement and simulated gemstones and

(iii) Colour enhancement of diamond as reported in the news media, which are baffling the gem market. Therefore, there is need for fostering gemological education for identification of natural gemstones and pursuing researches to combat the advent of synthetic gemstones and their stimulants in the market.

5.2 FAMOUS DIAMONDS OF INDIA

The most famous diamonds of the world like the Koh-i-Noor, the Regent, the Orlov, the Hope and the Dresden were only mined from India and as such bears to the testimony of the great heritage of gemstone resources of the country These gems were exhibited in USA, USSR, Great Britain and France as the greatest epitome of National History.

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Koh-i-Noor

The Koh-i-Noor which means the Mountain of Light is the most famous diamond of India described by the French traveler Tavenier, which had no doubt having a background of long legend and history. This fabulous piece of diamond weighing 186 carats was first worn by King Karna in his forehead to acquire invincibility in the epic age of the Mahabharata and sustained to travel down the centuries gathering interesting history to its credit to become an object of adornment in the Royal Crown Jewel of the Queen Elizabeth II of England.

It is said that the King Karna, used to wear a dazzling stone of light in his forehead to make him invincible by virtue of which he challenged the most valiant Pandava Arjuna in the Mahabharata War and registered a great fight before he is succumbed in the war. In passage of time a young woman discovered the piece of diamond accidentally and brought it to the village temple of Lord Siva, where the Brahmin Priest affixed the stone in the forehead of the statue of Lord Siva as the third Eye of the God which was illuminating splendidly. According to legend a wicked person once remained inside the temple stealthy to steal the stone and he was found dead when the door of the temple was opened in the next morning by the priest of the temple. The Brahmin priest said that "he who posses this diamond will posses the World, but he could also experience the misfortune, for which only God and a woman can wear this stone." This was found true in event of the fact that a good number of elites, those who owned this stone had a tragic fate including the King Karna and the Persian King Nadir Shah.

The chronical history of the Koh-i-Noor known from Baburnama, the memoirs of Babur, depicts that the famous diamond was once possessed by the Raja of Malwa. It is in 1304, Sultan Ala-ad-Din Khalji, the rule of Delhi seized the diamond from the king of Malwa. More than a couple of centuary later in 1526, Babur, the First Great Moghul invaded Northern India and founded the great Moghul Dynasty in Delhi after he defeated and killed Ibrahim Lodi in the battle of Panipath. The widow of Ibrahim Lodi offered the new ruler Babur number of gifts including the Mountain of Light, when he visited Agra on 4th May, 1526, who after seeing the stone exclaimed that the stone was so valuable which could cover one day expenditure of the world. The prestigious stone remained with the Moghul Emperors for couple of centuries as Moghul treasure. In 1739, the Persian ruler Nadir Shah invaded India and dethroned the ruling Emperor Mahmud Shah and looted the built of treasure of

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the Mogul empire including Peacock Throne and taken away to Persia. This time Nadir Shah did not get the trace of the Koh-i-Noor as it was safely concealed in the turban of the defeated ruler. The shrewd Nadir Shah came to know regarding this from his harem. Thereafter he invited Mahmud Shah to a ceremonial gathering where as per ancient custom, exchange of turban, if sought for was unavoidable. Nadir Shah meticulously pursued the customs and managed to posses the stone by exchange of turban tactfully. It is said after seeing the stone Nadir- Shad came to ecstasies and exclaimed Koh-i-Noor means "The Mountain of Light", after which the famous diamond was called as Koh-i-Noor. After the assassination of Nadir Shah in 1747, the Koh-i-Noor came to Afghanistan ruler Ahmed Shah Durrani in the year of 1751. In 1810, the Saddozai of Afghanistan established by Ahmed Shah broke up and his brother Shah Shujah, who was in possession of the Koh-i-Noor, sought asylum with the Sikh Ruler Ranjit Singh, who acquired the stone from Shah Shujah. The Sikh Ruler Ranjit Singh mounted the stone in a bracelet of enameled gold and kept with him till his death in 1839 and thereafter the 186 carat diamond remained in Lahore Treasury until 1849, in the same year following the defeat of Sikhs in the second Sikh war, Punjab was annexed by Britain and the Britishers confiscated the treasury of Lahore and sent the stone as a gift to the Queen Victoria. The queen of England got the stone fashioned into brilliant oval cut reducing the stone from 186 to 109 carats.

The Queen was superstitious and took cognizance of the old Indian legend and the prediction of the Brahmin priest, which said that the Koh-i-Noor will bring misfortune to him who will wear it, through not women. Therefore she said that when a diamond is inherited by a male sovereign, it should be worn only by his spouse, which is being scrupulously followed by the British Crown. In 1937, the stone was placed in the crown of the Queen Elizabeth, the wife of King George VI and since then the Queen mother alone has worn it on high occasions.

THE HOPE (The Grate Blue Diamond)

The most famous and fancy "the Great blue diamond" of repute today is the Hope diamond known for its striking violet blue colour and alarming history of bringing misfortunes to its owner. The author had the benefit of witnessing the famous blue diamond "HOPE" lying in Harry Winston gallery of Smithsonian Institute of Natural History in Washington DC of USA in May 2005, which hails from India. This piece of diamond owes its Origin to a crystal of 112.5 carat diamond acquired by French Merchant Jean Baptiste Tavenier from South India in 1642 on his visit to

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India. He then sold it to French King Louis XIV in 1668 on his return from India and Far East. King Louis XIV had re-cut the fashionable diamond into 67.5 carat and named it as Royal French Blue Diamond of the Crown. In 1792 in the French Revolution, the diamond was stolen from the Royal treasury and disappeared for 38 years to re-appear in London market in 1830. Henry Phillip Hope, a British banker and merchant purchased it for $ 90,000, who refashioned the esteemed gem to 44.52 carat after which it was known as "HOPE" diamond. It is only in 1890 the diamond was again repurchased by Francis Hope, the Duke of New Castle. In decades of destiny, the Hope diamond moved from one hand to the other and responsible for tolls and tragedies of its owner. In 1911, the Hope was purchased by Evalyn Walsh McLean for $ 1,54,000, who died in 1947. In the final phase of the stunning history of the HOPE, the Newyork jeweller Harry Winston purchased the stone from the Mac Lean Estate for more than $ 1,00,000 and donated it to the Smithsonian Institute of National History in Washington DC in November 1958, since when it is lying as pivotal exhibit with galaxy of other gems in Harry Winston Gallery of the Institute. as unique source of attraction the in the gallery.

Although the stone was in USA in most of the Twentieth Century since it was purchased by Evalyn Walsh McLean in 1911, it was never been formally graded. In December 1988 the, Gemological Institute of America learned that the Hope was not monitored for certain reason. The GIA took advantage of the situation, examined and graded the diamond and weighed it as 45.52 carats instead of 44.52 as evaluated earlier. The Hope diamond phosphorescences a strong red colour, which last for several seconds after exposure to short wave ultraviolet light. The blue colouration is attributed to the trace element of boron in the crystal lattice of the store.

It may not be out of place to mention that in 1988, a 54 carat blue diamond said to have been recovered from the gem gravel of the river bed of the Mahanadi around Boudh in the State of. This piece of gem was clandestinely smuggled to London and sold for a fabulous price of Rs. 5 crore.

THE ORLOV

Among the known historical diamond of significance, a 194.75 carat diamond retained its original Indian diamond cut was known as Orlov, the Sun of the Sea, now being adorned as treasures of Kremlin in USSR.

It is said that the stone served as an eye of Lord Brahma in a Hindu Temple of Trichinapally in Mysore. In mid Eighteen Century during Karnatak war, a French

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soldier, who deserted the army, noticed the stone which was a remarkable blue green stone that gained the name of "Sun of the Sea". The soldier having assumed the character a native devotee stole the idol's eye and escaped to Madras. He then sold it to an English Captain of the ship for $10,000/ -, who in turn sold to a British Jeweller for $60,000/-. After change of ownership, a Persian merchant namely Khojeh went to Amsterdam and sold it to Prince Grigori Grigoryevich Orlov of Russian Court in 1773 for an amount of $ 45,000/- after several road of negotiation as the Prince was frantically in search of a fabulous gilt for Catherine, the Great to regain his lost favour. The Prince went back to Russia and presented the stone to Catherine II. The Empress never wore the stone, but as a token of consolation to her erstwhile lover bestowed Orlov's name in the stone and mounted it in imperial scepter, which is lying as an admirable exhibit of the Kremlin in Soviet Union.

THE REGENT

The Regent, a remarkable piece of diamond adorning the French crown also owns its origin to India. In 1701, a mine worker recovered a 410 carat diamond from Partial on the river Krishna in Andhra Pradesh. The worker feigned to be hurt and kept the stone inside the bandage and managed to escape to a sea coast. There he revealed it to the Captain of a Vessel. The Captain, offering half the value of stone at the cost of a safe passage to a free country, took him on board, but threw him to the sea and possessed the diamond and quickly sold it to a Indian Gem merchant for about $ 5,000/-. The Indian merchant in turn sold it to Sir Thomas Pit, the Governor of Fort St. George, Madras in 1702 for $ 1,00,000/-. Thomas Pit entrusted his son Robert to bring the diamond to London and got it fashioned by a British Jeweller Haris converting it to a splendid cushioned shape brilliant cut piece of diamond of 140.5 carat, which was named as Pitt Diamond. In 1717, the Duke of Orleans, Regent of France brought Pitt Diamond for $ 6,00,000/-. This famous diamond remained as REGENT. In 1792 it was stolen from the treasury of France along with other jewels during French Revolution. Fortunately in 1793, the Regent was discovered in Paris hidden by a swindler and came back as Crown Jewel of France. In 1797, the famous diamond was pledged by the Republican Government to German and Holland bankers for the money for which the expenses of the Nepoleonic war was to be met. Later, redeemed by Napoleon, he mounted the stone in the hilt of his sword and carried at his coronation in 1804. In 1825, Charles X, wore the Regent at his coronation and it remained in the Royal Crown till the Napoleon III and later put on display as Pride of the nation in the Apollon Gallery of Louvre Museum in Paris.

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THE DRESDEN GREEN

The Dresden Green derives its name from the capital of Saxony, which is the finest fancy green diamond of the world originating from India. The diamond is said to have been recovered from the diamond mines around Golconda, near Indian City of Hyderabad. The green and irradiated diamonds are most commonly found in alluvial deposits, derived from primary source of diamondiferous volcanic pipe rocks. The green colour is usually caused by the bombardment of alpha particles of the radioactive components into the crystal lattices of the diamond crystals, once comes in contact with a radioactive source.

Marcus Moses, one important diamond merchant of the Eighteenth Century brought this large green diamond from India to London in 1726. He made an unsuccessful bid to sell the diamond to the King George I of England and Federick Augustus I, King of Poland. It is only in 1741, the diamond was sold to Frederick Augustus II at the great annual Easter Fair at Leipzig by a Dutch merchant Delles for $ 30,000/-. The King commissioned Dinglinger, the jeweller of the royal court, who set the diamond in Decoration of Golden Fleece, which lasted for only a few years. This was again in 1753 was refashioned by another jeweller Pallard in Vienna by resetting it in another Golden Fleece incorporating the famous piece of Green diamond. The Dresden green was again refashioned in 1768 by another Jeweller Dissbatch with another two white brilliant diamond and the famous fancy diamond is in display for more than two centuries in Albertinium museum of the Dresdem in Poland.

In 1988, the Gemmological Institute of America evaluated the gemological characters of the Dresden and graded the same, which was categorized as a green diamond of extraordinary quality and graded as a rare II diamond of 41.7 carats. The Dresden was exceptionally transparent despite its considerable thickness. In fact, its symmentry was excellent and polish was remarkable although being cut prior to 1741.

The famous diamond was brought to the Harry Winston Gallery of the Smithsonian Institute of Natural History in October 2000 and placed near the famous Hope diamond for display a year and returned back to Polland to the Albertinium museum, where it is lying at present as one of the finest epitome of Natural History.

5.3 COLOURED GEMS OF INDIA

Apart from these formal diamonds of the country, there are also rich deposit of coloured gems like Emerald, Ruby, Sapphire, Aquamarine, Garnet etc., for which

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India was in lime light. The Harry Winston Gallery of Smithsonian Institute of Natural History Washington DC, USA is also adorned with a rare piece of Emerald earlier possessed by the King of Jodhupur mined from Rajstan Emerald mine. As per BBC London, a fabulous piece of Emerald which was recovered from Guchepada Antarla area of Balangir district of Odisha state was smuggled out to United Kingdom and sold for a fabulous price Rs. 5 crore. The Cornflower blue sapphire of Doda district of Kashmir is acclaimed to be the most fascinating sapphire of the world.

Gemstones were used as a source of power, prestige, adventure, scientific interest, fashion, culture and aesthetics. Queen Elizabeth II collected Timur Ruby Necklace and Williamson Pink diamond as her private royal collection, which were separately exhibited from ceremonical crown jewels in the tower of London. During colonialisation, Royal Jewels of different countries came to England especially the jewels of Moghul Emperor and Kandy Ruler of Srilanka. K. S. Ranjit Singhjee, the Maharaja of Nawanagar and the distinguished statesman and sportsperson purchased the Queen of Holland, the diamond of Indian origin, which was exceptionally flawless diamond of 135 carats. The Indian royal crown of last Moghul Emperor Bahadur Shah, a gold crown set with turquoise, rubies and diamond and famous Kohinoor diamond bears the testimony of the rich heritage of gemstones of India in the World scenario.

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CHAPTER VI

NATIONAL POLICY OUTLOOK FOR GEMSTONE

6.1 INTRODUCTION

Gemstone Industry occupies an important position in our National Economy. The impact of Mineral Industry in any National economy has always led to the formulation and development of a National Mineral Policy. The gemstone industry in India is having a speedy growth and account for contribution of 17.20% of total export merchentise of the country. But it totally dependent upon the import of rough gemstone. The diamond and coloured stone roughs are imported from the oversea countries by the fashioning industry of the country for faceting, value addition and export of fashioned gemstone. Although there is scope of boosting up of the export of fashioned gemstone, there has been constraint of input of gemstone roughs from domestic sources to the fashioning Industry which comes on the way for accelerated growth. Therefore it has become essential for the policy maker to adopt a suitable policy of for exploration, development and mining of gemstone in the country to achieve sizable and sustained production of gemstone to meet the challenge of fashioning Industry.

In early eighties of the 20th Century, the discovery of various gemstone in Balangir, Sambalpur, Dhankanal, Kalahandi, Phulbani and Sambalpur Districts of Odisha from where Aquamarine, Garnet, Zircon, Tourmaline, Ruby, Sapphire, Chrysoberyl, Alexandrite, Topaz, Iolite and Diamonds were recovered by clandestine diggers, attracted the gem traders of the country and abroad culminating into a gem rush. The gemstones of distinguished colour, clarity, caratage were traded in different trading centers in the western Odisha at Kantabanji, Guchepada, Antarla, Bolangir and Boudh and smuggled out of the state incurring loss of revenue to the state. These wide spread illegal activity of mining and trading of gemstone aroused media hype and public criticism for inaction of the State Government to curb these illegal activities and eventual loss of revenue to the state. These issues also rocked the Orissa Legislative Assembly which urged the State Government to take immediate and adequate steps to marginise these illegal activities in the framework of the law of the land. The gemstone operation of such diverse nature and dimensions however wanted huge resources, logistic and human resources to tackle the problem. Therefore, the Govt. of Odisha took a policy decision to reserve the gem rich districts of the

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state to be exploited by the state owned public sector as per Rule 75 of Mining Concession Rule, 1960. The Govt. of Odisha notified on 31.10.1981 that the explaratory mining and exploitation of gemstones in Bolangir, Sambalpur and Dhenkanal districts will be done by the Odisha Mining Corporation Ltd. (OMC), a State owned public sector undertaking on experimental basis. As leading gem rich state of India the Govt. of Odisha, not only exploited gemstone resource of the state by its PSU OMC, but also in a decade of working (1981-1991) reviewed and revised its modality of gemstone exploitation by Public Sector, Joint Sector, Joint sector and Private Sector Enterprises, which have been discussed subsequently. The experiments done by the State Government above for adopting different modality of gemstone exploitation from time to time in the State was quite interesting and its outcome will have guidelines for formulation of a National Policy outlook for development of gemstone resources of the country. Similarly in early eighties, there was also clandestine mining and trading of Chrysoberyl Cat's Eye, Alexandrite, Garnet, Topaz, Zircon, Tourmaline in Vishakapatnam, Vijayanagaram, Karur and Kurnool District of Andhra Pradesh, which led the Govt. of Andhra Pradesh to take a policy decision to work the gemstone deposits by it PSU Andhra Pradesh Mining Development Corporation Ltd too.

The New Economic Policy adopted by India in 1992 envisaged harnessing potentialities and initiatives of Private Sector to boast economic growth of the Country. With the above objective in view a New National Mineral Policy was announced by Govt. of India in March, 1993. The Policy emphasized on induction of foreign technology and foreign participation in exploration and mining of high valued minerals and encouragement of foreign investment in Joint Venture equity promoted by Indian Companies. This attracted Oversea Multinational Companies, who visited Indian mineral deposits and showed their keen interest for investment and development of mineral deposits of the country, especially Gold and diamond. The Govt. of India, in April 1994, organized an International Round Table Conference at New Delhi on Foreign Investment in Exploration and Mining Industry in India in order to have a meaningful interaction with the investor on the above issue and development of an understanding for foreign direct investment in India. In the above conference, several recommendations were made with specific emphasis an legal and fiscal changes in Mining Legislations which led the Govt. of India in framing new enactment by way of modification of MMRD Act, 1957 by the Ministry of Steel & Mines, Govt. of India. In an International Workshop on Diamond and Gold – Strategies for Development, organized in Bhubaneswar in November, 1994, where world players of Diamond and

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Gold operations participated, the author and Sri U.S. Bhatia focused on the introduction of three tier Mineral Concession (Exploration Permit, Prospecting License and Mining Lease) for a term of 30 years and rationalization of royalty of diamond and gemstones in keeping with the prevailing rates in developing countries, which led the Govt. of India to amend its MMDR Act, 1957 introducing Reconnaissance Permit.

In India except for underground Mining operation for Emerald is Rajasthan and systematic mechanized mining operation in Majhagawan pipe in Panna Diamond mines of NMDC in Madhya Pradesh and Jillingdhar Ruby Mines of OMC in Odisha, both being in public sector, the rest of the mining operation of gemstones are sporadic manual operations. In view of the nature of gemstone deposits of our country, it is not only essential to adopt suitable method for mining operation to win the gemstones quickly to avoid heavy expenditure on security cover, but also desirable for fixing suitable agency for proper exploration, exploitation, utilization of and conservation of gemstones.

In India there is scope for appreciation and growth of export potentialities of Gem and Jewellery in the world market especially Diamond Jewellery, which has lead Govt. of India to take new initiatives for promotional support and creativity in Jewellery and commitment for formulation of a more comprehensive National Trade Policy. Therefore, it was essential is part of Govt. of India and the gem rich states of the country to address these issues and frame a National Policy on growth and development of Gemstone Industries in the country.

6.2 GEMSTONE POLICIES IN ODISHA

6.2.1 POLICY RESOLUTION 1981

In event of discovery of gemstones in the Western districts of the State, the Govt. of Odisha took a policy decision that the exploration, exploitation and marketing of gemstones of the state has to be under taken by the Odisha Mining Corporation Ltd. a PSU of the state in mining sector formed under Company Act, 1956. This policy resolution and initiative was first of its kind in India for development of gemstone deposits. The Government of Odisha in its notification of the steel and Mines Department on 31.10.1981 resolute that OMC shall undertake exploratory mining and exploitation of precious and semiprecious stones in Bolangir, Sambalpur, Dhenkanal district as an agent of the State Govt. as per Rule 75 of Mining Concession

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Rule, 1960 on experimental basis for a period of one year under the terms and conditions contained in the notification which made as follows.

1. The question of entrusting the work of explorative mining and exploitation of precious / semi-precious in the district of Bolangir, Samblapur, Dhenkanal through the Odisha Mining Corporation Ltd. was engaging the attention of State Government for some time past. After careful consideration it has been decided that M/s Odisha Mining Corporation Ltd. will undertake explorative mining and exploitation of precious / semi-precious stones in the above mentioned districts as an agency of the State Government an experimental basis for a period of one with effect from 31.10.1981.

2. The precious / semi-precious stones collected during exploration / exploitation by M/s Odisha Mining Corporation Ltd. will be kept in safe custody in embedded chest in the nearest treasury / sub-treasury and the same will be disposed of by public action at regular intervals after giving wide and all India publicity.

3. Precious stone and Semi-precious stone are minerals within the meaning of the Mines & Minerals (Regulations & Development) Act, 1957. Winning of such minerals either from the private land or from the Government land amounts to mining operation. Under Sub-section (1) of Section – 4 of the aforesaid Act, no person shall undertake any prospecting or mining operation in any area except under and in accordance with the terms and conditions of Prospecting Licence or, as the case may be, a mining lease granted under this Act and the rules made there under. Any person, who contravens the provision of the aforesaid sub-section is liable for punishment under section 21 of the Act. It is, therefore, obligatory on the part of any person / persons not to dispose of elsewhere, any precious / semi-precious stone found in their private land in the aforesaid three districts and to handover the same to the Odisha Mining Corporation Ltd. who will keep them in safe custody in embedded chest in the nearest Treasury /Sub-treasury for eventual auctioning of the same after giving wide publicity. As an incentive to the owner of the private lands, 50% of auction value of the stone will be given to these persons. The OMC Ltd. will also consider given some provisional payments to them pending final payment.

The terms of reference of such operation by OMC involves;

- Exploration and exploratory mining of precious and semi precious stones in the above districts.

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- Purchase of gemstone from the diggers, these who collect gem from their tenanted and Govt. land
- Stocking of gemstone collected from exploration and exploratory mining and procurement in safe custody
- Sale of gemstones by Public auction.
- In case the operation ends in a surplus for OMC, a part of the surplus will accrue to the state Government, the detailed terms of which will be decided later. In case of eventual loss in the operation, the question of compensating the loss to OMC partially or fully may have to be considered by the State Govt. later.

As per the notification, the OMC was to pay 50% of the projected auction value of the gemstone to the diggers an incentive. It was further stated that OMC may consider making provisional payments to the diggers, those who have collected the stones from their own tenanted land pending final payments to be made after auction of the lot of gemstone. This directive of the Government however posed problems for OMC for going ahead with collection of gemstones because it was not possible for OMC to assess the auction value of gemstone lot at the time of purchase from the diggers. That apart if OMC takes the recourse of final payment after auction sale, the value may eventually appreciate or depreciate and OMC would have put to loss in case of depreciated value of the lots. More over it was also not possible to keep an account of so many individual lots and their seller to settle the final payments, after auction sale of gemstone. The Govt. of Odisha settled these issues on request from OMC and sorted out the lacunae in the payment terms to the diggers by their notification dated 15.12.1983, which directed OMC to make a final payment of 50% of the assessed value of gemstone to the diggers at the time of taking delivery of the gemstone.

6.2.2 EXPLOITATION OF GEMSTONE BY PUBLIC SECTOR - THE ODISHA MINING CORPORATION LTD. (OMC)

Exploration : With the above objective in view, the Odisha Mining Corporation Limited, as a major corporate diversification effort organized exploration, exploratory mining and procurement of gemstone in the above gems rich districts in 1982. OMC pursued exploration by geological mapping, trenching, pitting and washing of heavy minerals in different gemmiferous belts of Kalahandi, Sambalpur, Bolangir and Phulbani districts and identified different minable blocks for exploratory mining of gemstones. OMC

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assigned late M.N. Vishwanatha, Gemmological Consultant for appraisal of gembelts identified by OMC, who after due appraisal recommended 7 potential belts in Kalahandi district and 9 potential belts in the rest, for detailed exploration. Besides, Dr. J.N. Kanis and Dr. J.L.S Garcia, Gemmologist of International repute also visited Bolangir and Kalahandi districts of Odisha as per request of OMC and made an appraisal of the colluvial, alluvial and eluvial gem deposits and suggested for exploration and exploratory mining activities.

In the block period of 1982-90, the exploration input by OMC;

i. Delineated 20 gem belts in six districts of the state for pursuing exploration.

ii. Identified 9 gemmiferous blocks for detailed exploration for Iolite, Gamet, Aquamarine, Alexandrite and Sapphire in Bolangir, Kalahandi and Sambalpur district.

iii. Demarcated three minable blocks at Jillingdhar (Ruby), Budhapada (Rhodolite garnet) and Hinjlibahal (Ruby) by detailed exploration resulting in assessment of reserve of gemstone and preparation / approval of Mining plan for grant of Mining Lease in order to take up mechanised mining and washing for production of gemstone. This was a major contribution in the history of gemstone mining in the country.

Exploratory Mining: OMC pursued exploratory Mining in Damjhor (Gamet). Jillingdhar (Ruby) in Kalahandi and Sangamra (Aquamarine) and Badamal (Aquamarine) in Bolangir district. The mining operation was basically carried out by semi mechanised operation in absence of proper process equipments and with tight security cover and produced 7,04,306, grms of gemstone including 1,31.993 grms of Aquamarine, 5.44,275 grms of Gamet and 28,837 gms of Ruby .

Purchase of Gemstone: For procurement of gemstone, 9 purchase centers where organized by OMC in various gem belts of Bolangir, Kalahandi, SambaJpur and Phulbani districts. The purchase of gemstone were done from the diggers by a Purchase Committee associating an experienced Valuer, after initial guidance by Hindustan Diamond Company and Gem and Jewellery Export Promotion Council. Mumbai. OMC Procured 1,32,25,052 gram of gemstone including 1,22,527 grams of Aquamarine, 21,518 grms of Ruby, 1,29,80,605 grms of Garnet and 73,302 grms of Iolite.

Sale of Gemstones by Public Auction: The stock of gemstones mined and purchased was kept in safe custody in each point of inspection. OMC sold these gemstones by

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public auction, one experimental auction organized at Jaipur in May 1985 and another two public auctions organized at Bhubaneswar in 1986 and 1990 in which both national and international bidders participated. Most of the gemstone roughs were sold by auction yielding remunerative price.

Human Resources Development : OMC made Human Resource Development efforts and trained two geologists in the Gemological Institute of India, Mumbai for identification and characterization of gemstone in 1982 and trained four other geologists in the above institute subsequently those who took training of Gemmology. OMC promoted a lapidary training center at Bhawanipatna by Odisha State Co-operative Handicraft Corporation and trained 150 artisans for cutting and polishing of gemstone to be eventually absorbed in the growing lapidary units of the State.

Promotion of Lapidary Units : OMC also promoted 6 lapidary units in the state for cutting and polishing of gemstone including three in Public Sector and three in Private Sector and supplied for fashioning of Gemstone.

Profitability : On the end of the block period of 1982-90, it was assessed that OMC in the Gemstone sector had a turnover of Rs. 1.00 crore having available surplus of Rs. 20 lakhs which was remitted to Govt. of Odisha, thus making profit in the Project.

6.2.3 EXPLOITATION OF GEMSTONE BY JOINT SECTOR- GEM CORPORAITON ODISHA LTD. (GEMCO)

At such a juncture, when OMC was fully equipped and geared up for exploitation of gemstone resource of the state by acquiring technical knowhow and expertise, two renowned private entrepreneurs having expertise in mining, fashioning and marketing in the country and abroad, namely S. Gupta & Co. Mumbai and Pramod Kotawalla, Jaipur approached the State Govt. and showed interest in development of Gemstone Industry in the state by way of mining, fashioning and marketing of gemstone. The Govt. of Odisha on the other hand desired to have speedy development of gemstone resources of the state in under to have sizeable return by optional utilization of the gemstone deposits involving those private player. As a result M/s S. Gupta & Co. and Sri Pramod Katawalla, as per the directive of the State Government, singed a MOU with OMC on 22.11.1988 for mechanized mining of gemstone deposits by deployment of imported mining equipments and setting up of Lapidary Centres in Bolangir and Bhawanipatna for fashioning and value addition in Collaboration with the Odisha Mining Corporation Ltd. with equity participation of 49: 51. A joint sector company in the name and style of GEM CORPORATION OF ODISHA LTD. (GEMCO)

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was floated under companies Act., 1956 and incorporated on 4.1.1989, OMC having an equity holding of 51% and the private players 49% in which the author was as founder director. As per the Joint Sector agreement, the immediate objective of GEMCO was to undertake mining operation in Jillingdhar (Ruby), Hinjilibahal (Ruby) and Budhapada (Rhodolite garnet) Mining Leases of OMC in Kalahandi district for gemstones and setting up two modern Lapidary Centres in gem rich districts at Bhawanipatna and Bolangir. Based on the exploration efforts by OMC, three identified mining blocks in Jillingdhar, Hinjilibahal and Budhapada were identified and mining plans were prepared by the author and approved by Indian Bureau of Mine based on Concept of Explaratory mining operation and beneficiation by heavy mineral separation. OMC entrusted these areas to GEMCO for mining operation in a time bound manner as per the approved mining plain on 10.08.1990. It was planned to have indigenous equipments for mining operation, where as for beneficiation, it was decided to import a mobile processing plant for Jilingdhar and a pleitz type jig for Hinjilibahal from M/s P A Campbel Ltd., Australia. This imported plant was to be duplicated for Budhapara. Although GEMCO initiated mining operation in Jillingdhar in 1993 and they could not import the mobile processing plant and complete mining operation in five years.

The GEMCO also initiated procurement of gemstones from some purchase centres of Koraput and Kalahandi districts, which was subsequently discontinued.

GEMCO also decided to setup two Lapidary units, one in Bhawanipatna and another at Bolangir having a capacity of production of 3.60 lakh carats of faceted stones with as financial outlay of Rs. 9.6 lakh per unit. The Lapidary unit at Bhawanipatna was operational in February 1990 for which gemstone roughs were supplied by OMC on spot sale. The unit was operational for some time and discontinued forthwith. As per the Joint Sector agreement, although the second unit was to commence in Bolangir, it could not be organized by GEMCO.

The GEMCO could not do the mining of ruby deposit in Jillingdhar in site of the fact that a mobile processing plant acquired by the Govt. of Orissa on UNDP assistance was given as lease to GEMCO to facilitate completing mining operation. The GEMCO has also not taken interest to open up Hinjilibahal and Budhapada as per Joint Sector agreement.

Therefore the concept of working of gemstone by Joint Sector Company in the state did not achieve tangible results and faced major set back in spite of the fact

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that world class players on gemstone mining, fashioning and marketing were involved in the Joint Sector enterprise.

6.2.4 WORKING OF GEMSTONE BY ASSISTED SECTOR

The private collaborators of GEMCO pleaded for greater autonomy in working of gemstone for which the equity participation in GEMCO was revised as per directives of the State Govt. dated December 11, 1991, OMC holding only 11% and the private collaborators holding 89% in the company, converting the status of the company from joint Sector to Assisted Sector. The Govt of Odisha, although reserved the gemstone rich district of the state for exploration and exploitation by OMC under Rule 75 of Mineral Concession Rule 1960, directed that the Mining leases granted to OMC for gemstones will be worked by OMC or GEMCO in Assisted sector only. As per this directive, the GEMCO operated Jillingdhar Ruby Mines from 1993 by deploying Mobile Processing Plant and could not successfully operate the mines as described in 6.2.3. They did not take up mining operation in Hinjliabhal and Budhapada Mining Leases and effective steps for development of lapidary units as agreed by them. Therefore, no tangible development has been done by GEMCO in the field of mining and fashioning of gemstone in the state even in Assisted sector.

6.2.5 WORKING OF GEMSTONE BY PRIVATE SECTOR

In the same notification dated December 11, 1991, the Govt. of Odisha held that the remaining gemstone areas of the district will be demarcated and auctioned by OMC to private sector mining entrepreneurs on the basis of competitive bids. As a result, 12 blocks were notified and auctioned by OMC at a base price of Rs. 20 lakhs, out of which 5 blocks, one for Aquamarine in Bolangir district and four for Sapphire in Kalahandi district were taken on auction by different entrepreneurs for Rs. 22 lakhs. But no successful mining operations could be launched in these blocks due to lack of expertise and enterprise.

The Government of Andhara Pradesh taking clue from this policy, indentified seven potential gem areas in the State and auctioned the same to private sector mining houses. The floor price for each block was Rs. 5 lacs and as against a base price of Rs. 35 lacs in seven blocks, the Government earned a revenue of Rs. 5 crores, which was no doubt remunerative. But that State Government later did not see whether these mining blocks were being worked as per the law of the land with due regard to mining, conservation, utilization and value addition of the gemstone in these blocks.

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6.2.6 GEM POLICY 1991

In exercise of the powers conferred under Rule 75 of the M.C. Rules, 1960 and in suppression of the Notification No. 13578/SM dated 07.11.91 of the Department of Steel & Mines, the State Government vide notification no. 14861/SM dated 11.12.1991 appointed M/s Odisha Mining Corporation Ltd. as an Agent of the State Government to explore and exploit the gemstone / semi-precious stones in the districts of Koraput, Kalahandi, Phulbani, Dhenkanal, Sambalpur and Bolangir for period of 3 years from the date of the notification on the following terms and conditions.

1. The gemstone / semi-precious stone in areas leased to O.M.C shall continue to be exploited by OMC or GEMCO as the case may be under terms and conditions prescribed by Government from time to time.

2. The other gemstones / semi-precious stone bearing areas in the above districts other than diamond bearing areas shall be worked by OMC Ltd. through sub-agents to be selected on the basis of competitive bids invited through newspapers on terms and conditions to be approved by Government.

3. 80% of the bid money collected from the successful bidders shall be deposited with Government.

This policy decision to entrust private sector entrepreneurs for mining and trading of gemstones in the state was significant deviation from the initial policy outlook of 1981, which no doubt deferred the development of gemstone industry in the State. The private players having acquired the auctioned gemstone blocks from OMC and with a legal standing of having lease for operating gemstones indulged in illegal mining and trading of gemstones in other sector, which defected the very purpose of curbing clandestine operation in the state. Similarly in lapidary front, six lapidary units were operating the state for cutting and polishing of gemstone, with firm assurance from OMC for supply of gemstone rough to the units. In event of the fact that OMC as per this policy was forced to auction its stock of gemstones, debarred from pursuing exploratory mining and discouraged to purse further purchase of gemstones, these Lapidary Units were still operating by procurement of roughs from illegal source. As a result by introducing this policy 1991, the state Government tacitly encouraged clandestine mining, trading and lapidary units in the state.

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6.2.7 GEM POLICY 1994

1. The Notifications assigning the gemstone bearing districts to the Odisha Mining Corporation (OMC) as the Agent of the State Government under rule 75 (2) of the M.C. Rules, 1960 will be withdrawn. Recourse to the said provision shall be limited to situation where an illegal mine is detected and the Government wishes to handover the same to OMC immediately to prevent theft of gemstones. OMC may apply for grant of P.L/M.L. over the said area which will be considered on top priority.

2. Government will take expenditious decision in respect of the pending applications of OMC for grant of P.L / M.L.

3. OMC shall undertake prospecting and / or commercial mining of the areas held by it on PL / ML either on its own or sub-lease the same to Joint Ventures or Assisted Companies for similar purpose.

4. OMC shall take vigorous steps to form Assisted Companies / Joint Ventures and sub-lease gemstones bearing areas to such Companies for prospecting and / or mining. The Corporation shall select its Assisted Company / Joint Venture partners from amongst / Public / Private Sector firms having rich experience or sound track record and good financial standing, through public advertisements. The share-holding of OMC in a Assisted / Joint Venture Company shall be 11% in the minimum or more at its discretion. A condition shall be imposed on each Assisted Company / Joint Venture to put up at least one lapidary unit for training of the local artisans / youths in cutting and polishing of gemstones.

5. Director, Mining & Geology, Odisha shall prepare list of gemstone bearing areas for reservation under Rule- 74(1) of the M.C. Rules, 1960 for prospecting by the Directorate and submit the same from time to time to the Government. Government in Steel & Mines Department shall process such proposals on priority basis and issue the necessary notification. OMC shall remain in constant touch with the Directorate to select, out of the areas so reserved, such ones which have promising potential for gemstone and apply for grant of M.L. After scrutiny, Director, Mining & Geology, Odisha will propose to the Government for de-reservation of the said areas under rule -74 (3) of the M.C. Rules, 1960. Government in Steel & Mines Department shall process such proposals on top priority basis for issue of the de-reservation notification. The liaison between

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the OMC and the Director, Mining & Geology, Odisha shall be done so closely and in such regular internals that the de-reservation Notification of the selected areas and the submission of application by OMC for grant of PL/ML over the same is simultaneous. Such of the areas out of the areas notifies under rule – 74(1) at the M.C. Rules, 1960 in which OMC is not interested, shall be thrown open for grant to other applicants.

6. Mining & Geology, Odisha shall undertake much larger programmes of intensive prospecting of gemstone-bearing areas during the current year and in 1994-95 & 1995-96 so that identification of all the promising areas in the State are completed by April., 1996. The process of reservation by Notification under rule – 74(1) of M.C. Rules, 1960, selection of the areas by the OMC and simultaneous steps for submission of application for M.L. by the OMC and issue of de-reservation notification under Rulel – 74(3) of the M.C. Rules, 1960 shall be repeated at regular intervals.

7. While considering applications for the grant of M.L. in respect of areas thrown open as described in para (5) above, the State Government will give weightage in favour of :

   (a) A public sector undertaking having experience in gemstone prospecting / mining / processing / marketing

   (b) Any other public sector undertaking

   (c) A public limited company having experience in gemstone prospecting / processing / mining / marketing

   (d) Any other Public Limited Company

   (e) A Private Limited company having experience in the field of gemstones prospecting / mining / processing / marketing

   (f) Any other Private Limited Company

   in that order.

8. The daily collections of gemstone through mining by the OMC or an Assisted Company / Joint Venture / any other lessee shall be sealed, properly labeled and kept in a secure safe. The sealed packets kept in the safe shall be opened once in two month in the presence of a committee comprising of a representative each of the :

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(a) OMC / Assisted Company / Joint Venture / Lessee,

(b) Director, Mining & Geology, Orissa,

(c) A Government approved valuer,

and the contents shall be valued and catalogued. OMC shall prepare a list of approved valuer with the approval of its Board of Directors and submit the same for Government approval. On approval, services of any of the valuers in the list can be used for the above purpose.

9. Government in the former Mining & Geology Department Notification No. 11735, dated 31.10.81 as amended by Notification No. 14407, dt. 15.12.83 have permitted OMC to operate purchase centers to procure gemstone from a person found in this private land. The Corporation shall operate as many centres as may be considered necessary for the said purpose. Such purchase centres shall work in rotation once in every 2 months at least for 2-3 consecutive days. During the period, a representative each of the OMC, OMG and the approved valuer shall remain present at the centre and jointly assess the price of the gemstone offered by a person found in his private land. OMC may procure the gemstone from the said person at a negotiated price which shall not exceed the assessed price. The price at which the gemstone is sold by the offered shall be the "Sale Price at the pit mouth" for payment of royalty at the rate prescribed in schedule (II) of the M.M (R &D) Act, 1957. OMC may operate the purchase centre on its own or authorize an Assisted Company / Joint Venture to operate the same. In case OMC is not willing to purchase the gemstone in the above manner, any Assisted Company / Joint Venture may then step in and purchase at price that may be reached by the operation of the market forces, the assessed value determined by the Committee being treated as the "Floor Price". The price at which the offerer sells the gemstone to the Assisted Company / Joint Venture shall be the "Sale Price at the Pit Mouth" for payment of royalty at the rate prescribed in Schedule (II) of the M.M. (R & D) Act, 1957.

10. The implementation of the New Gemstone Policy shall be reviewed by the Principal Secretary, Steel & Mines Department with the Director, Mining & Geology, Odisha and Chairman-cum-Managing Director, Odisha Mining Corporation every two months.

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This Policy however did not have much impact on the modality of operation and could achieve the desired objectives.

The Gemstone Policy, 1994 could not have much impact and could active desired objectives due to the following constraints;

(i) Under the policy a poor farmer or villager getting a piece of gemstone could sell it only to OMC whose representatives are not readily accessible and who take their own time for assessment of value and payment. As such he preferred to sell it clandestinely at throw away price through a middle man who took it away and sold it at higher price at centres of gemstone trade. This transaction deprived the finder of a legitimate price for the gemstone and the Government of the royalty. The clandestine trade only benefitted the middle man and lower level officials to the detriment of the finder and the Government.

(ii) Large Scale scientific and commercial exploitation of the gem bearing areas through public or private sector did not take place. The only joint venture exploiting a limited lease-hold area also did not achieve the desired results. Due to lack of exploitation of gem bearing tracks, the State Govt. have not been able to benefit from this sector. In fact, the royalty received annually from gemstone is only of the order of Rs. 4-5 lakhs which can increase manifold through a rational policy of wide scale exploitation of gemstone bearing areas.

(iii) Lapidary units for cutting and polishing of gemstones which would have provided local value addition, large scale employment and income to the State Exchequer became a casualty of the policy. Under the prevailing regime of clandestine extraction and illegal trading of gemstones, genuine entrepreneurs wanting raw materials for the lapidary units were completely starved. A few lapidary units that come up in the State closed down for want of raw materials.

Therefore, the State Govt., in 1996, formed a Committee under the Chairmanship of the Commissioner-Cum-Secretary, Department of Steel & Mines to recommend measures for formulation of a new policy with the following reform agenda;

(i) To ensure higher income for the State from mining of gemstone and local lapidary units.

(ii) To ensure greater employment through gemstone mining, cutting and polishing activities.

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(iii) To stop clandestine extraction and trading and ensure higher income to Govt. and poor villagers.

(iv) To ensure transparency in the matter of grant of lease / license for extraction and trading of gemstones.

The Committee formed by the State Govt. recommended measures for foundation of a new policy, which includes,

(a) Throwing open 18 prospected tracts to prospective entrepreneurs including OMC for grant of mining lease,

(b) Time – bound exploration programme for the unprospected areas,

(c) Continuance of OMC as agent of the State Govt. for the unprospected areas and granting of contract / sub-lease to entrepreneurs under OMC for exploitation of the areas,

(d) Selection criteria for parties for grant of mining lease,

(e) Grant of trading licence to parties including lesees for purchase of gemstone from all available sources including tenants in a competitive manner,

(f) System of assessment of royalty on pre-determined pit's mouth value etc.

6.2.8 GEMSTONE POLICY 1998

The State Govt. after careful consideration of the prevailing policy, the legal frame based in this work, the recommendations of the Committee, etc and keeping in view the overall development of gemstone resources in the State laid down a new Gemstone Policy, 1998, as described in the following paragraphs.

All the gemstone areas can be divided into 3 Categories.

(a) 18 gem bearing tracts which have been indentified and prospected by DMG and OMC under UNDP Project

(b) Remaining 10 tracts indentified under UNDP Project where prospecting has started but not completed.

(c) Other areas in the State which have not at all been prospected so far.

Of the gem bearing tracts already explored (presently eighteen), Government would decide the tracts to be given to OMC under Mining lease. The balance tracts would be deserved and thrown open for grant of mining lease to private parties.

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As indicated in (b) above, prospecting of 10 gemstone bearing tracts identified under the UNDP Project has been started and is expected to be completed shortly. The Director, Geology/OMC will be instructed to complete the prospecting work expeditiously. After prospecting is completed, these 10 tracts would be thrown open for grant. Till that time, OMC would continue to be the agent.

The 3rd category is the areas which have not been prospected so far as indicated at (c) above. OMC may continue as an Agent of the State Govt. under Rule 75(2) of MC Rules, 1960 till prospecting is completed over those areas. The areas not at all identified and prospected so far are located in Bolangir, Sambalpur, Subarnapur, Kalahandi, Nawapara, Phulbani, Koraput and other districts. The Director, Geology will chalk out a time frame within which the prospecting of these areas will be completed along with OMC. As soon as the prospecting is completed, it will be thrown open for grant of ML as at (a) above.

Selection criteria for grant of Mining Lease

Preference in grant of ML would be given to the parties on the following parameters

(a) The financial standing of the party including a commitment that it will put in an investment of atleast Rs.100 lakhs within the specified period in the shape of plant and machinery/other processing facilities .

(b) Technical expertise available with the applicants.

(c) Parties who have the experience of dealing with gemstone and processing thereof including lapidary operations.

(d) OMC may be given preference subject to their ability to handle the areas.

Conditions of lease

(a) The mining lease will be granted for a period of 20 years .

(b) A lapidary unit will be set up within a period of 5 years from the date of execution of the lease.

(c) Supply of gemstones to local lapidary units on preferential basis.

Trading Licence

Gemstones are an important Foreign Exchange earner and it may contribute sizeable revenue to the State Exchequer. With this in view, the Committee has

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recommended introduction of Trading Licence for collection of gemstones inside the State.

Gemstones are minerals which come under the purview of Mines and Mineral (Regulation & Development) Act, 1957. Mining of such minerals from any land - Govt. or private-amounts to mining under Section -4(1) of MM (R&D) Act. No person can undertake prospecting or mining operations without taking PL/ML from Govt. over the area from which the gemstones are found. As such, any one other than a lessee finding a gemstone from an area outside the leasehold area had to surrender the same to Govt. To encourage people finding gemstones from sporadic areas to surrender the same to Govt., the State Govt. had adopted the policy that the finders would be paid 50% of the value of the gemstones by OMC which worked as the agent of Govt. for the entire State. Govt. allowed OMC to retain the gemstones on payment of royalty as per rules. However. this arrangement has not been very helpful as the finders in interior areas are tempted to sell the gemstones clandestinely to middle men operating in those areas and offering low but ready price for the gemstones. OMC had been getting only Rs.30-40 lakhs worth of gemstones per year through such purchases which are only an insignificant fraction of the total transactions. As such OMC has suspended its purchasing operations for the last two years. Accordingly, a more rational and workable arrangement has to be devised to enable the finders to freely sell the gemstones found any where from non lease hold areas to the authorised licencees who would pay the royalty to Govt. for the same and be permitted to dispose of the gemstones in an open and transparent manner.

The best way to achieve this objective is to appoint a number of Trading Licensees under the Odisha Minerals (Prevention of Theft, Smuggling and Unlawful Activities) Act 1989 and also induct them simultaneously as sub-agents of OMC in respect of all non leasehold areas for which OMC continues as agent of the State Govt. Under this arrangement, all lessees and selected persons/agencies with financial credibility and business experience, can be appointed as trading licensees and sub-agents of OMC to collect gemstones from any finder and dispose of the gemstones in any manner they like after payment of royalty to Govt. The finders can collect from any locality (outside the leasehold areas) for which OMC continues as agent of Govt. This modification of the existing policy will induce competition among a number of trading licencees to buy gemstones from the finders by paying a better price to them on competitive basis and ensure payment of proper royalty by the trading licencees to State Govt. The whole operation will become open and transparent, the

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finder will get a better price, the Govt. will get higher royalty and also substantial licence fees from the trading licencees. Local lapidary units would also be able to purchase their requirement from the trading licencees which they are not able to do at present due to prevailing clandestine operations. At any time, Govt. can part with a certain percentage/amount collected by them from license fees and royalty in favour of OMC, their agent, through budgetary mechanism.

As already mentioned, trading license for all minerals are granted by the Competent Authority under Section-6 of the Odisha Minerals (Prevention of Theft, Smuggling and Unlawful Activities) Act 1989. Rules have been framed for such purpose under Section-37 of this Act. To facilitate the arrangement mentioned above, the rules will be suitably amended to provide for appropriate trading licences for gemstones to lessees and other selected persons for procurement and disposal of gemstones from any non-leasehold areas under the following terms and conditions:

a. Payment of an annual licence fee of Rs. 1 lakh

b. Security deposit of Rs. 1 lakh from each licensee(in shape of pledged certificates etc., interest on which will accrue to the licensee but in the event of forfeiture, to the State)

c. A licensee should satisfy the following conditions:-

   i. He should be a lessee in respect of a gemstone bearing areas

   ii. If he is a non- lessee, he should have good financial standing with appropriate registration under Sales Tax/Income Tax act

Among non-lessees, preference will be given to those who have gem processing units in the State or give a definite commitment for setting up such units inside the State within a period of 5 years.

Conditions of Licence

(a) The licence will be granted initially for a period of one year which is renewable annually. For each renewal. the licensee would have to pay a licence fee of Rs.1 lakh. Renewal can be made on satisfactory performance in terms of the provisions of Acts and Rules.

(b) The licensee would pay royalty on the gemstones sold to him from different sources on the basis of the sale price determined as per rules. The assessing authority will verify the sale price from time to time to ensure that appropriate

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royalty is realised by Govt. Subject to payment of royalty, the licencee can dispose of the stock in any manner he likes.

Royalty

Prior to 11.4.97, royalty on gemstones paid to State Govt, was calculated on the basis of sale price at pit's mouth as per the Second Schedule of the M.M (RD) Act, 1957. This Act does not define the manner in which such sale price at pit's mouth is to be determined. State Govt. can formulate the modalities for fixation of this price. There are three ways in which it can be assessed.

(a) by auction,

(b) valuation by a group of experts including Govt. approved valuer and

(c) on pre-determined value

The Committee has suggested that the Joint Venture partners/lessees may not agree to dispose of and Government cannot force them for sale the gemstone produced / purchased by them through open auction. On the otherhand, valuation by a Group of Experts as envisaged in 1994 Policy encountered several difficulties particularly in respect of reasonableness of the valuation of the material and delay in valuation. In all fairness of things, valuation should be transparent. But gemstone trading does not lend itself to the type of transparency consistent with public service accountability.

Besides, it may not be practical and economically feasible to form a large number of Valuation Committees to value the gemstone on day to day basis for a. large number of lessees and trading licences throughout the State.

The said Committee has, therefore, suggested to assess advance royalty "on pre- determined pit mouth value basis" and appointed a Sub-Committee consisting of Director, Mines and Director, Geology, GM (Geology) OMC and one Deputy Director, Geology to suggest the "pit's mouth value" of different grades of various gemstones. The Sub-Committee's recommendations which have been accepted by the State Government for the valuation of different grades of various gemstones taking into account the sale price of gemstones, auctioned in the past by OMC, suggested price of GSI and information on this collected from different Gem Trading Agencies are at Table 6.1.

A Lessee /Trading Licencee will be allowed to dispose of his gemstones in the normal course of business. He will pay advance royalty at the rate prescribed by

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Government of India on the basis of self-assessment at the rate of "pre-determined pit's mouth value" indicated in table-6.1. The advance royalty will be adjusted when the ultimate sale price is determined under the guidelines issued by Govt. of India/ State Govt. This kind of advance royalty discipline needs to be enforced since, at present, most of the gemstones are sold outside the State and it might take considerable time and effort to reach a conclusion regarding the sale price on the basis of which royalty would be recovered from the parties. The Government will not put any hindrance in the free movement of goods but can make periodic checks. The pit's mouth value indicated in Table-6.1 would be reviewed after a year by a Committee.

The new Gemstone Policy, 1998 enumerated above is expected to have the following advantages :

(i) Opening up of the gemstone tracts will ensure large scale scientific exploitation of resources resulting in higher employment and royalty.

(ii) The lessees would be able to gradually set up lapidary units inside the State for value addition and other local lapidary units would be able to procure raw material from the lessees as well as the trading licencees. All these would help create greater employment and generate higher revenue through sales tax etc. on value added products.

(iii) Introduction of trading licences will encourage entrepreneurs / businessmen to carry out free trade in gemstone and stop clandestine activities and smuggling. Competition by many trading licencees to purchase from finders will ensure reasonable higher price to the latter. Besides, considerably higher trading licence fees will add to the Govt. income in addition to royalty from the licencees.

(iv) This policy will bring bout transparency and openness to exploitation of gemstone resources in the State while augmenting employment and State resources.

11. The Gemstone Policy in Odisha 1998 will come into effect from the date of issue of the Notification.

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Table 6.1: PIT Mouth Value (PMC) of Gemstones for fixation of Royalty

Sl. No.	Name of the Gem Stone	Colour, other characters	Price range per gram in Rupees
1	2	3	4
1	Ruby (I grade)	Purplish red / flawless transparent	More than I carat6000/- less than I caret 200/-
2.	Ruby (II grade)	Purplish red with slight flaw and less transparency	25/-
3.	Ruby / Corundum (III grade)	Purplish to reddish, translucent to opaque	2/-
4.	Sapphire (I grade)	Dark blue to blue, transparent, flawless	More than I carat 6000/- Less than I Carat 200/-
5.	Sapphire (II grade)	Dark blue to bluish, Violet blue with slight flaw and less transparency	25/-
6.	Sapphire / Corrundum (III grade)	Bluish, translucent to opaque	2/-
7.	Alexandrite (I grade)	Clean, transparent with sharp colour change from green to violate / red	1000/-
8.	Alexandrite (II grade)	Semi transparent to translucent with less flaw, colour change from green to violate / red	500/-
9.	Emerald (I grade)	Dark green, transparent, Flawless	5000/-
10.	Emerald (II grade)	Dark green to light green with less transparency and flaw	500/-
11.	Green beryl (III grade)	Dark green to light green, translucent to opaque	50/-
12.	Aquamarine (I grade)	Bluish to sea green transparent, without flaw	More than 10 gms 400/-

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13.	Aquamarine (II grade)	Bluish to greenish and lighter shades, semitransparent	50/-
14.	Aquamarine (III grade)	Fractured	2/-
15.	Chrysoberyl, Cat's eye (I grade)	Yellowish green, transparent with chatoyancy, eye effect	More than I gm 1500/-
16.	Chrysoberyl (II grade)	Yellowish green, transparent to semi transparent	150/-
17.	Chrysoberyl (III grade)	Greyish, greenish, translucent to opaque	4/-
18.	Rhodolite Garnet	Reddish-purple, transparent without flaw	More than 2 gms 10/-
19.	Garnet	Red, transparent without flaw	1 gm 0.50
20.	Garnet	Pink	3/-
21.	Garnet	Pinkish red	1.50
22.	Garnet	Honey yellow to yellow brown	Big Size 5/- Small Size 2/-
23.	Topaz	Coloured, Clean	More than 2gms 1.50
24.	Topaz	Coloured, fractured	1/-
25.	Topaz	Colourless fractured	0.10
26.	Others		0.10
27.	Iolite	Blue, transparent flawless	More than 5gms 6/-
28.	Iolite	Fractured	0.10
29	Sillimanite, Cat's eye (Fibrolite)	Grey with cat's eye effect cabochon grade	2/-
30.	Moon Stone (I grade)	Milky, fairly transparent with chatoyancy	1/-
31.	Moon Stone (II grade)	Milky, translucent to opaque with / without chatoyancy	0.50
32.	Amethyst	Violet	0.50

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33.	Apatite	Blue, greenish, blue transparent	0.50
34.	Tourmaline	Blue, green, transparent flawless	10/-
35.	Citrine	Yellow, transparent flawless	0.50
36.	Smoky quartz	Grey, flawless	0.50
37.	Rock crystal (quartz crystal)	Colourless, transparent flawless	0.10

N.B.: The rate of Gemstone will increase with increase of weight & size.

6.3 POLICY FOR EXPLORATION AND MINING OF DIAMOND IN INDIA

6.3.1 Introduction

Diamond Gemstone sector occupies an extremely important position in Indian economy. The export of cut and polished gemstone has registered remarkable growth and increased from Rs. 9 crore in 1970-71 to Rs. 28 crore in 1980-81, Rs. 2641 crore in 1990-91 and Rs. 33,500 crore in 2002-03. The Gemstone Industry is totally dependent upon the import of rough diamond. For export of the cut and polished stones of above order, massive import of rough diamonds mostly from Diamond Trading Company, London, are done as the production of Indian diamond is limited to 54,000 carats per annum.

In exercise of the powers conferred under Rule – 75 of Mineral Concession Rules, 1960, the Govt. of Odisha appointed M/s Odisha Mining Corporation Ltd. as the agent of the State Government to explore are exploit the diamond resources in the districts mentioned below until further orders on the following terms and conditions.

1. Sonepur
2. Bolangir
3. Nawapara
4. Kalahandi
5. Nawarangapur
6. Koraput
7. Malkangiri
8. Sundargarh

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9. Dhenkanal
10. Anugul
11. Phulbani
12. Boudh
13. Bargarh
14. Sambalpur
15. Jharsuguda
16. Deogarh

(i) OMC will undertake prospecting / Mining for diamond in these districts in joint / assisted sector partnership with the companies selected through advertisements in national / international papers in addition to correspondence with parties who have expressed interest in the exploration / exploitation of the Odisha's Diamond resources.

(ii) OMC will apprise the offers received after detailed discussion with the parties and come up with specific recommendation to the Government regarding their proposed partnership, their areas of operation, the terms of their collaboration with OMC and other connected matters.

(iii) The final decision in all these matters shall rest with the State Government.

Pursuant to liberalized National Mineral Policy, March 1993, and policy decision of the State, the Odisha Mining Corporation Ltd. on behalf of Govt. of Odisha, called for Global tender to pursue exploration and mining of diamond in Odisha, and obtained good response from Australia, London and Canada based multinational companies having expertise in diamond exploration and mining like CRA Exploration, Ashton Mining, Cluff Pacific Resources of Australia, De Beers of London and Leader Mining Company of Canada for taking up the Diamond Project in the State. These multinational companies also emphasized on issues to be quickly addressed and resolved to facilities participation and investment in diamond sector by way of making legal and fiscal change in mining legislation by introduction of Reconnaissance Permit and rationalization of royalty structure.

6.3.2 Exploration Permit

The state of art technology of exploration of diamond consist of Airborne magnetic survey to delineate noisy magnetic response, supported by ground based

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geochemically scanned indicator minerals, sampling to identify Kimberlite / Lamphroite pipes, pursuing core drilling in anomaly zone to determine the diamondiferous Kimberlite / Lamphroite pipes and evaluation of pipes by extensive core drilling and bulk sampling for assessment of incidence and grade. This high technology operation requires high risk expenditure and also time frame. The exploration programme requires higher level of expenditure, may be minimum US \$ 20 per KM^2 for 1st two years, US \$ 35 per KM^2 for next two years and US \$ 50 per KM^2 for 5th year onwards and minimum time period of 5 years from search to selection of mining block. Therefore, these Investors have opted to have their threshold conditions in their project proposal, which include grant of minimum project area of 200 sq.kms as Exploration Permit for five years, to be progressively reduced and handed over to State, 50% by second anniversary, 75% by fourth anniversary from the date of commencing of the project and residual area being converted to Prospecting License.

6.3.3 Royalty Structure

In the provision of second schedule of MMRD Act, 1957, there is 20% royalty on the pit mouth value of diamond, which was quite higher than the royalty in most diamond producing countries. In view of fact, the IRR of a diamond project is directly related to the royalty structure, they emphasized on the reduction of the royalty at par with other diamond producing countries of the world.

6.3.4 Mining Legislation

An International workshop on Diamond and Gold – Strategy for Development was organized by Department of Steel and Mine, Govt. of Odisha and the Odisha Mining Corporation Limited in association with UN Department for Development Support and Management Services (UNDDSMS) and the Society of Geoscientists and Allied Technologists (SGAT) in November 1994, in Bhubaneswar which was largely attended by world leaders in diamond exploration and mining. The author as General Manager of OMC was the convenor and led the pivotal role in organizing this workshop which was a landmark in technological innovation on exploration of diamond and gold beside policy outlook. The workshop while having an in-depth discussion on various issues taking stock of current status of exploration, evaluation and development of diamond and gold deposits in India, the author G.H. Khuntia and U.S. Bhatia focused on immediate need for legislation in changing in MMRD ACT, 1957 by introduction of Exploration / Reconnaissance Permit for grant of larger areas for Diamond and Gold exploration and reduction of royalty structure of 20% on Pit mouth value of diamond.

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Consequent upon the recommendation of this workshop a committee was setup by Govt. of India, under the chairmanship of the Secretary, Ministry of Mines for recommendation for amendment of the said MMRD, Act on above issues. As per the recommendation of Committee, Mines and Minerals (Regulation and Development) Act, 1957 was amended and was effective from 20th December 1999. In this amended Act a new provision of Reconnaissance Permit has been introduced, distinct from Prospecting License, for grant of large area. The royalty structure for diamond has also been reduced from 20% to 10% of pit mouth value by amendment of section 9 of the MMRD Act, 1957, which constituted first steps of reformed agenda for exploration and development of high valued minerals in the country.

6.4 NATIONAL GEMSTONE POLICY

Similarly in coloured gemstone sector, major policy issues like building geological database for exploration, identifying suitable agency for mining operation for production of gemstone roughs, revision of royalty structure, promotion of Lapidary Industries for boosting export of processed stones are still to be addressed and resolved to complete reform agenda to augment gemstone industry in the country. There are seven (7) major issues of Gemstone Industry in India.

6.4.1 Geological Database

Geological data can be collected and collated from various like Satellite Imagery, remote sensing, aeromagnetic high resolution and radiometric data for mapping and identification of gem bearing area. In our country, most of these data are generated by Govt. Agencies. We are yet to arrive at a broad policy for pricing and access to these data by private / public sector agencies. In view of the fact that basic objective of acquisition of these data are to augment mineral development, these data should be available to the mining house on cost basis. Beside, it would be only prudent to draw a distinction between regional data and data pertaining to a target area. In the former case the pricing should be of moderate nature, where as in case of later the pricing should be on the basis of cost incurred.

Besides Data banks of the Government agencies like GSI, IBM, NGRI, and that of public sector undertaking like NMDC, MECL and OMC need to be updated and all report available for public and private sector mining house. Similarly Geological data generated by private sector mining house like ACC, RTZ, De Beers, AMIL should also be updated and submitted to the state. This can be ensured through periodic reporting system. In case the mining house withdraw from the area, the geological data of the

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same area should be freely available to incoming licensee. This will not only enable him to benefit from the data, but also avoid duplication of work.

6.4.2 Agency for Mining of Gemstones

The Gemstone deposits of India are mostly small, shallow and sporadic in nature being associated with host rocks. In view of its mode occurrences, it is not only essential to adopt suitable method of mining operation with effective security cover, but also essential to fix suitable agency for exploration, mining and utilization of gemstone from security and conservation point of view. The gem mining operation around the world irrespective of their scale involves excavation of host rocks scrubbing, attritioning, washing, screening, jigging and tabling operation for which process equipments are essential for successful operation.

As per Dr. Jan Kanis, UNDP Consultant state controlled gemstone mining operation in Tanzania, Burma, Russia and Mozambique have been a failure and gemstone industry run by private sector in Brazil, Thailand, South Africa etc. are running in profits. But the Indian experiences discussed above shows that state controlled OMC worked gemstone profitably inspite of their lack of exposure to gemstone industry earlier whereas the private sector operators were utter failure. Therefore, the best option for exploration, mining and marketing of gemstone in our country will be joint sector company formed with State Mining Corporation for investment, mining, conservation, utilization and security point of view. It is essential for Government of India and Gem producing state to take a policy decision to form joint venture company in each gem producing state to undertake exploration, mining and marketing of gemstone leaving private sector to develop lapidary units for cutting and polishing for value addition and export. Many foreign collaborators have shown interest for development of coloured gemstone deposits in our country, who should be authorized to purchase gemstone from local diggers by organizing Purchase Centres in the gemmiferous belts of the state through a Purchase Committee assisted by experienced Valuer in order to curb clandestine trade on gemstone.

6.4.3 Overseas Mining Operation

Besides, coloured gemstone roughs are predominantly imported from Brazil, Madagascar, Sri Lanka, Burma, Vietnam and other gem rich countries of South Africa, which lacks in proper expertise of exploration and mining of gemstone. It is therefore suggested that the Government of India and gemstone rich states to negotiate with above countries to pursue joint venture mining operation in identified gem belts of

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their country for production and import of gemstone roughs for uninterrupted supply to Indian lapidary Industries. An understanding has to be reached with these countries that India with their personnel and expertise, will undertake exploration and mining of their gemstone deposit and in turn the said country will supply gemstone roughs to Indian lapidaries in moderate price it need be with buy back arrangement for cut and polished stones.

6.4.4 Royalty Structure

The present royalty pattern prescribed in MMRD Act, 1957 for coloured gemstone derived prior to the adoption of new Mineral Policy in December 1993. In view of the fact that the new Mineral Policy 1993 and amendment of MMRD Act, 1957 in January 1994 are aimed at attracting foreign participation and investment in mineral sector, it is necessary to revise the royalty structure of coloured gemstone in line with other gem producing countries. In India there was provision of 20% of Royalty on pit mouth value of diamond, which has been revised to 10% in order to attract foreign investment in diamond sector. Similarly there is provision of 10% royalty for coloured gemstone at its pit mouth, which is much higher than the gemstone producing countries like Tanzania, Zambia and New Southwales. In view of the fact, the IRR of a gemstone project is directly related to royalty structure, it is suggested that the royalty structure of coloured gemstone in India be urgently revised to the International norms.

6.4.5 Promotion of Fashioning Industries

India has been the leading country in Lapidary industry for ages. Jaipur is one of the five internationally acclaimed cutting and polishing centre of coloured gemstone in the world. But India is said to be the only country for cutting and polishing of small stone mostly by manual method. Most of the gemstone cut in Indian lapidary centres fetch low price because of their improper shape and calibration to be fitted into studded jewellery. Therefore, there is need for upgradation of technology and achievement of sophistication in lapidary skill in the country. In world scenario, the countries like Thailand, Germany, Israel, Taiwan and even China have modernized their lapidary skills and achieved perfect calibration, consummate polish displaying excellent internal reflection and colour and also attains large scale production. It is therefore essential to make concerted efforts to have technology upgradation of our lapidary units by modernizing the existing lapidary industries at Jaipur and Mumbai and to organize modern lapidary units in gemstone rich states of our country at Bhubaneswar, Visakhapatnam, Chennai and Bangalore.

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The Government of India and the gemstone rich states may have to adopt suitable policies for promotion of lapidary centres by providing incentive and infrastructures for establishing modern lapidary centres for production of sophisticated and calibrated cut and polished stone as outlined below:

(i) Making available land, water, electricity and industrial shed on subsidized basis.

(ii) Extending facilities of import of gemstone roughs on more rational basis and import of gem processing machineries, gem testing equipments, consumables like Diamond lap plates and Diamond powder.

(iii) Making new lapidary industries free from Income Tax extending Tax holiday of 10 years for the industries.

(iv) Organizing training centers for artisans for improvised cutting and polishing as human resources input for the industries.

(v) Organizing more international Gem and Jewellery exhibitions to promote sale of cut stones and studded jewellery.

(vi) Simplifying procedure for export of cut and polished gemstone.

(vii) Simplifying and liberalizing procedure for import of rough gemstone.

(viii) It is observed that some gemstone rough could only be processed after heat or radiation treatment. The sapphire of Kashmir is heat treated in Bangkok to get pleasing and uniform blue colour, which fetches fabulous price in world market. The light coloured aquamaire after heat treatment displays excellent colour of uniform blue, which fetches high value. Similarly, colourless topaz on radiation treatment turns to attractive blue colour. But unfortunately there is limited scope for heat or radiation treatments in India. Therefore, it is necessary to develop heat / radiation treatment by Govt. initiative at Chennai, Bhubaneswar, Hyderabad and Raipur. These facilities obviously helps in importing gemstone roughs in lesser price and could be disposed off after value addition by way of enhancement of colour.

6.4.6 Promotion of Gemmology Education

Ever since the fascinating gemstones were known to mankind, man is intrigued with the activities of duplicating these natural stones because of its value, as a result of which most of the variants of gems are having their synthetic equivalent and stimulants. After mid twentieth century, when much of the facts were known to the

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Geoscientist regarding the origin of gemstone, the efforts of manufacture of synthetic stones have been enhanced to a great extent. At present the greatest challenges, the gemstone industry is facing is the massive influx of synthetic stones and their stimulants, which is bafling jewellers, traders and gemmologists and they are to be distinguished from their natural equivalents. Therefore, the science of Gemology has assured importance which is essential to combat this problem. It has become increasingly important that the education on Gemology has to be organized and popularized to foster knowledge of gemology for proper diagnosis and segregation of synthetic and natural stones.

6.4.7 Promotion of Research and Development Centres

Natural Gemstone display its own and unique characteristics for which by examining a piece of gemstone a gemologist can depicts its source of origin and occurrence. The large scale production of synthetic gems and their stimulants including Ruby, Emerald, Sapphire, precious Opal and other variation of gems in the recent past is flooding the market leaps and bounds. Therefore, it is essential to organize more Research and Development Laboratories not only for proper identification and characterization of gemstone to determine its quality, but to differentiate and distinguish them from the synthesis and stimulants flooding the market. It is therefore suggested that the Govt. of India and the gem bearing states to take initiative to organize and set up Gem Testing Laboratories at Chennai, Bangalore, Hyderabad, Raipur for R & D on gemstone on the similar pattern of UNDP laboratory set up at Bhubaneswar.

It is observed that some gemstone roughs could only be processed by heat and radiation treatment. The Kashmir Sapphire is heat treated in Bankok to get pleasing and uniform blue colour, which fetches fabulous price in world market. The light coloured aquamarine after heat treatment displays excellent colour of uniform blue, which fetches high value. Similarly colourless topaz on radiation treatment turns to attractive blue colour. But unfortunately there is limited scope for radiation and heat treatment in India for enhancement of colour. Threfore, it may be perhaps prudent to develop more heat / radiation treatment facilities in Mumbai, Jaipur. It is essential to set up facilities for enhancement of colour by Govt. initiative at Chennai, Bhubaneswar, Hyderabad and Raipur. These facilities obviously helps in importing gemstone roughs in lesser price and could be disposed off after value addition by way of enhancement of colour.

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TOURMALINE
SCEPTER

This 4.5-centimeter-high bicolored natural tourmaline scepter owes its unusual form to a turbulent growth history. The crystal may have originally been complete, but changing chemical conditions subsequent to growth could have caused the crystal to go back into solution.

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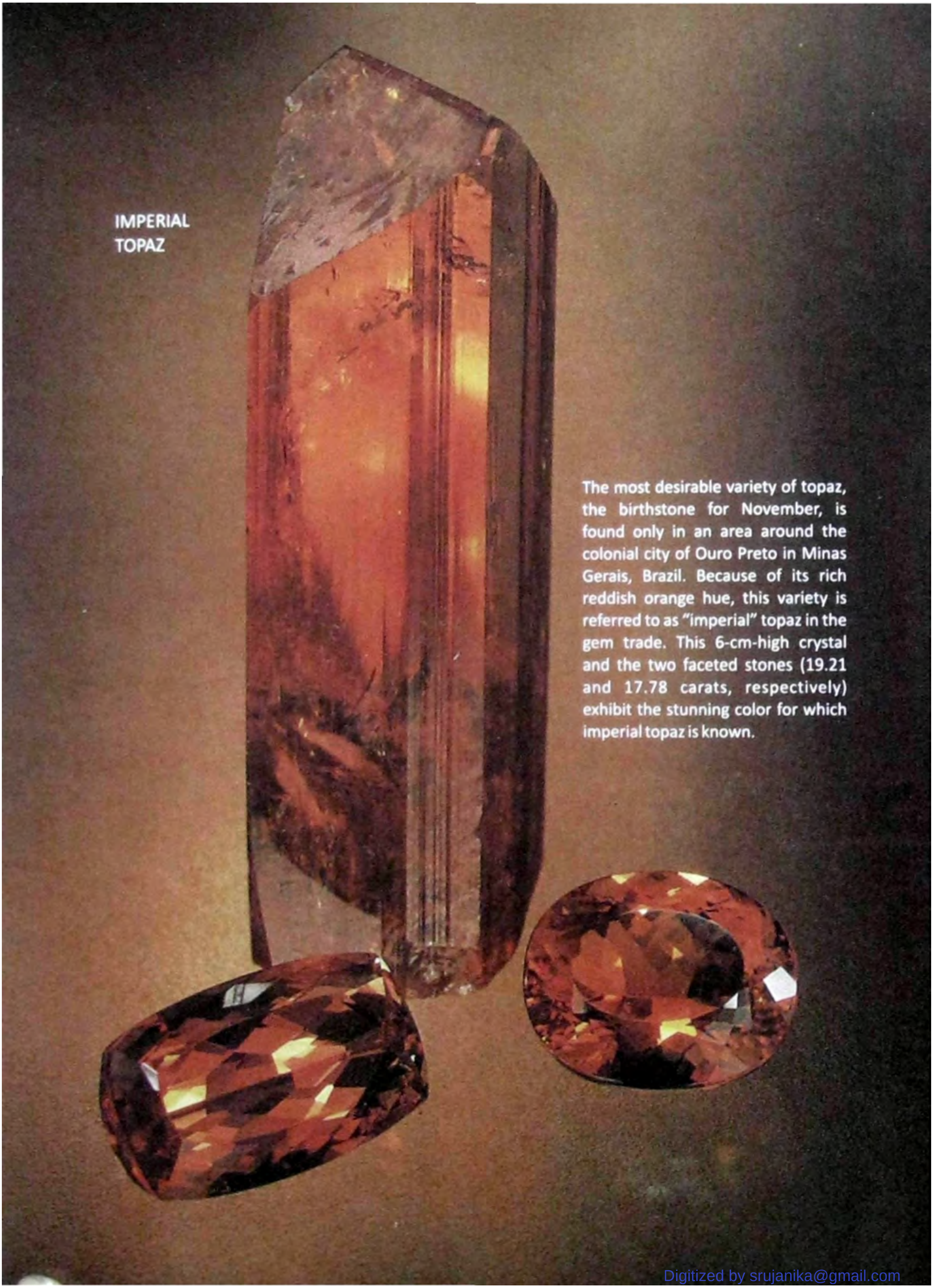
IMPERIAL TOPAZ



The most desirable variety of topaz, the birthstone for November, is found only in an area around the colonial city of Ouro Preto in Minas Gerais, Brazil. Because of its rich reddish orange hue, this variety is referred to as "imperial" topaz in the gem trade. This 6-cm-high crystal and the two faceted stones (19.21 and 17.78 carats, respectively) exhibit the stunning color for which imperial topaz is known.

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RUBY
EAGLE

Ruby is second only to diamond in hardness and therefore is very difficult to carve. Usually, only the most experienced lapidaries will attempt to work with this difficult precious gem. This exceptional ruby eagle, which weighs 809 grams and has a 36.3-centimeter wingspan, is the work of lapidaries from Idar-Oberstein, West Germany.

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RHODOCHROSITE

The rich red color of fine rhodochrosite makes this a popular mineral with sophisticated collectors. This 9-centimeter-high specimen of rhodochrosite with a beautiful spray of quartz was found in the lead-silver mines of Peru. It is now one of the most prized specimens in the mineral collection of the Smithsonian Institution.

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